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Hasegawa et al.

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(54) **SEWING MACHINE**

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(51) **Int. Cl.**

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D05B 19/12	(2006.01)
D05B 37/08	(2006.01)
D05C 9/06	(2006.01)

(52) **U.S. Cl.**

CPC ***D05B 19/12*** (2013.01); ***D05B 37/08*** (2013.01); ***D05C 9/06*** (2013.01)

USPC **112/470.05**

(58) **Field of Classification Search**

USPC 112/470.05, 470.06, 470.09, 98, 80.04, 112/80.23, 80.4, 102.5, 220, 249

See application file for complete search history.

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(57) **ABSTRACT**

A sewing machine may comprise a needle bar driving mechanism, a cutting needle rotation mechanism, and an embroidery frame movement mechanism configured to move an embroidery frame comprising a protruding portion. A cam member may be fixed to the needle bar and comprise a plurality of cams. A processor of the sewing machine may set a height of the needle bar to a specific position from a plurality of positions. Each of the plurality of positions may represent that each of the plurality of cams is able to contact with the protruding portion. The processor may instruct the needle bar driving mechanism to move the needle bar to the specific position and instruct the embroidery frame movement mechanism to move the embroidery frame to a position where the protruding portion is able to contact with one of the plurality of cams.

8 Claims, 21 Drawing Sheets

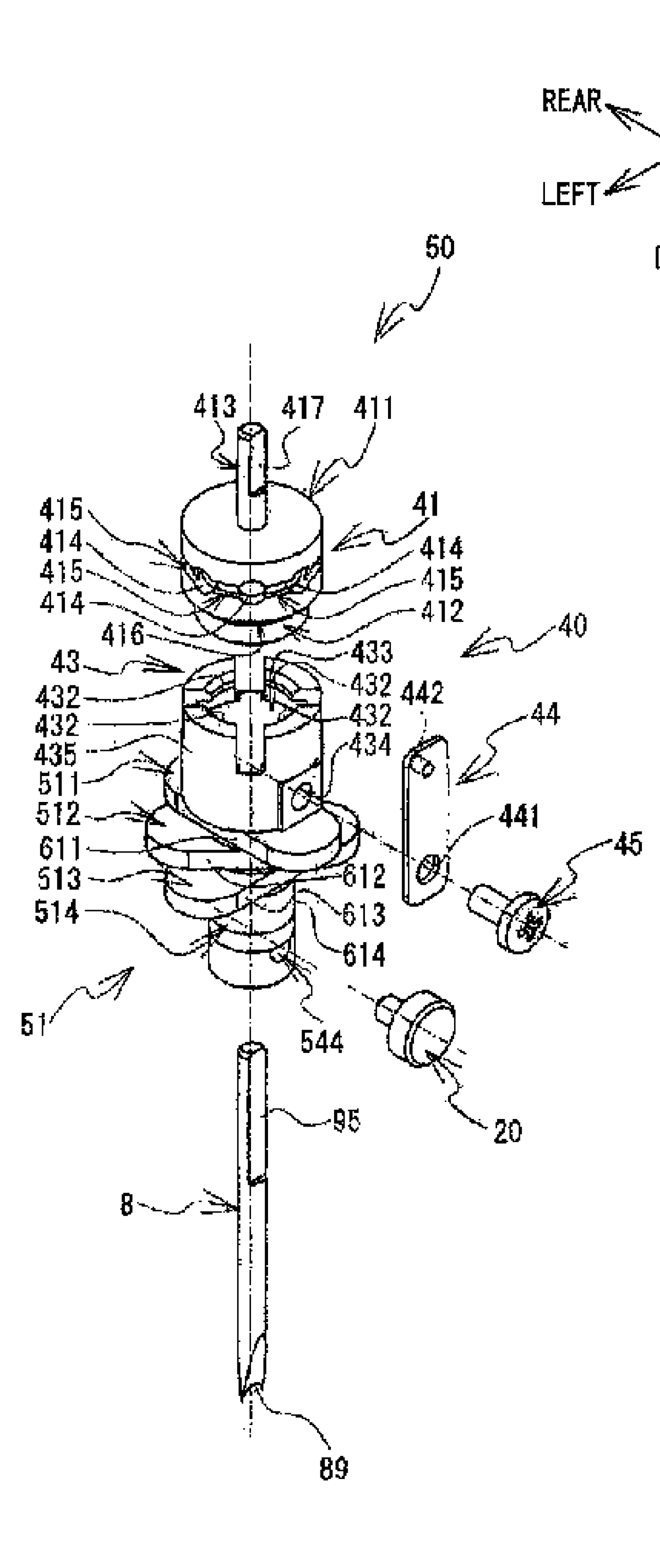
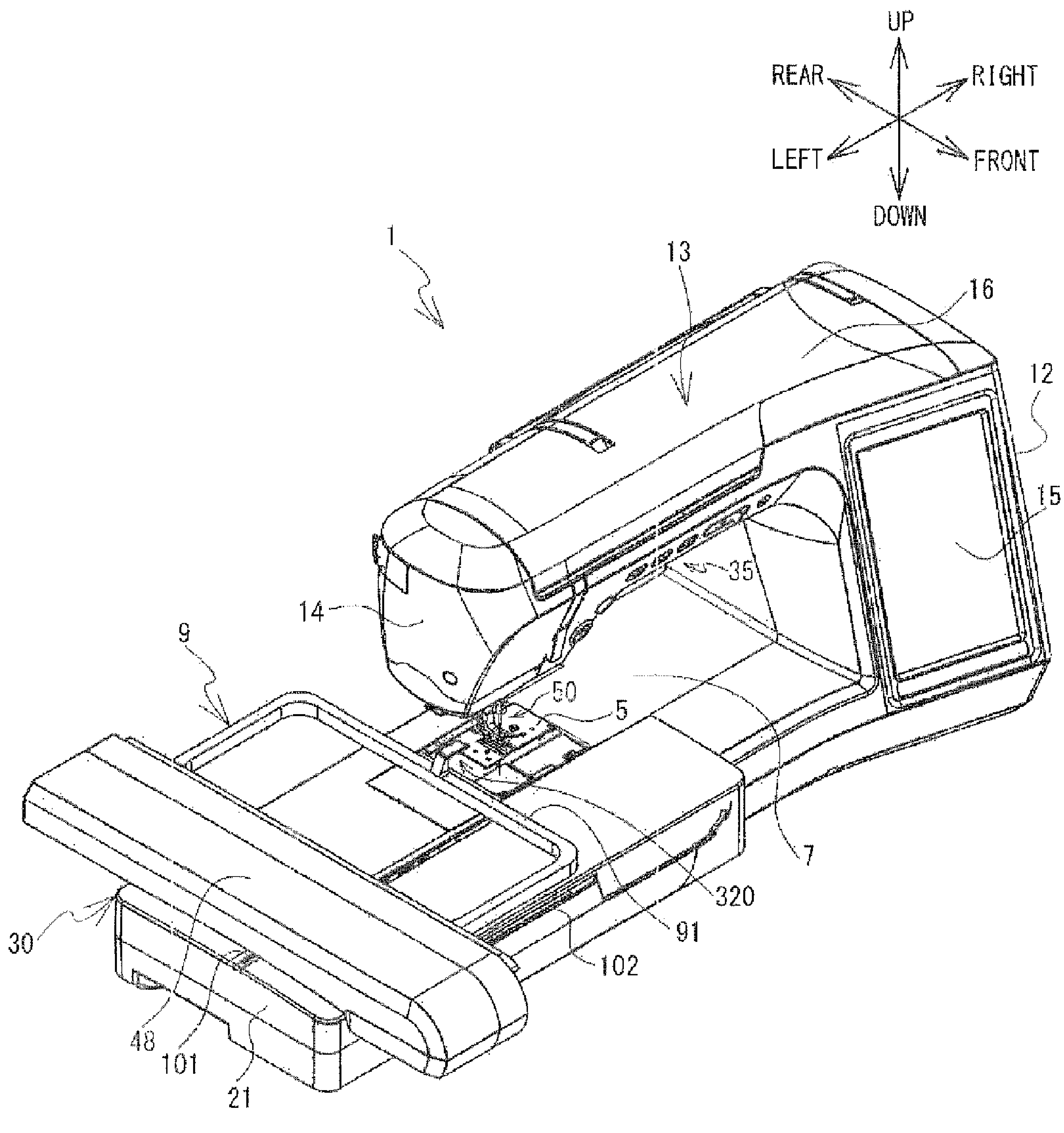


FIG. 1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DOWN
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13
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12
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35
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9
50
5
7
320
91
30
102
48
101
21

FIG. 2

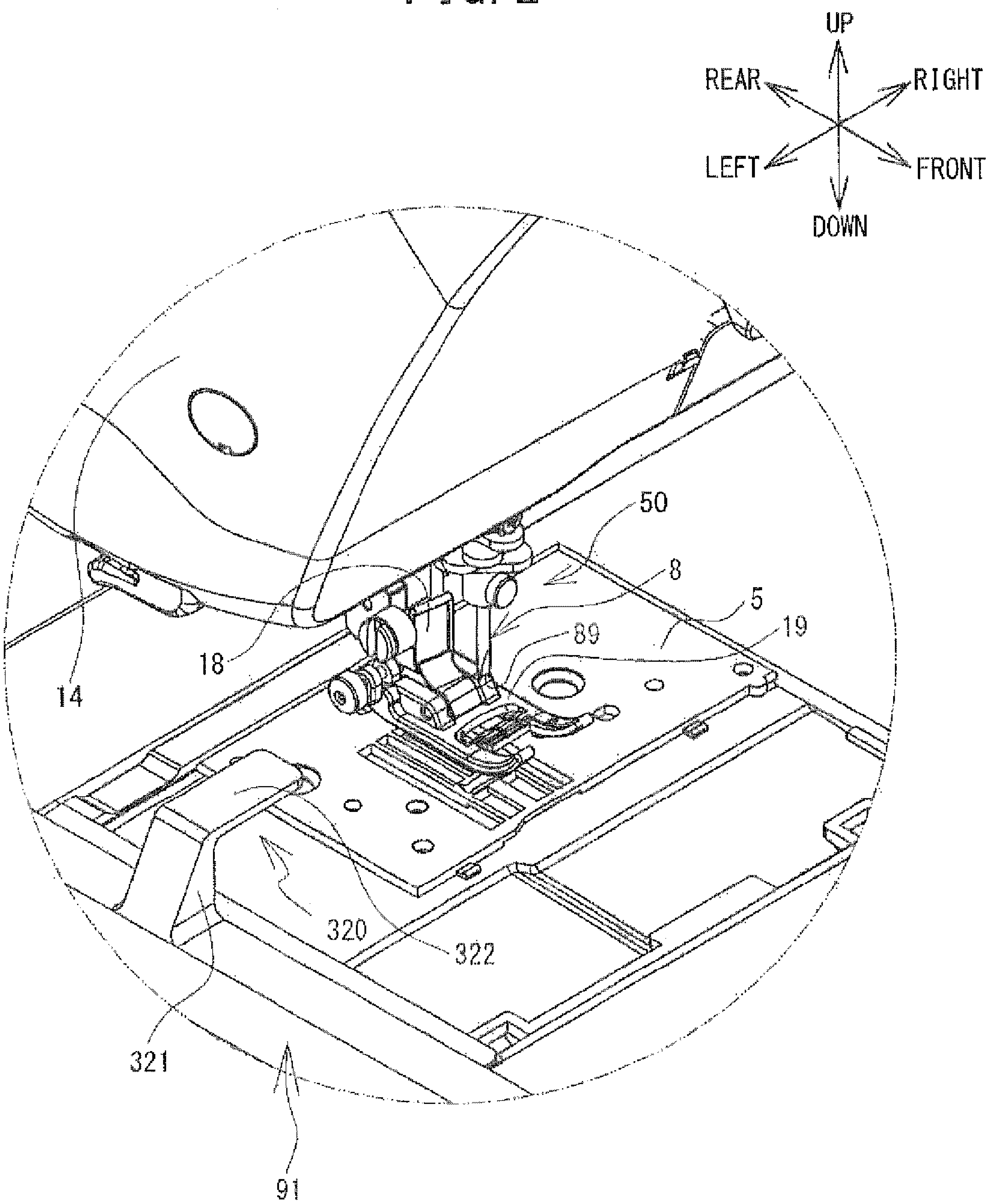


FIG. 3

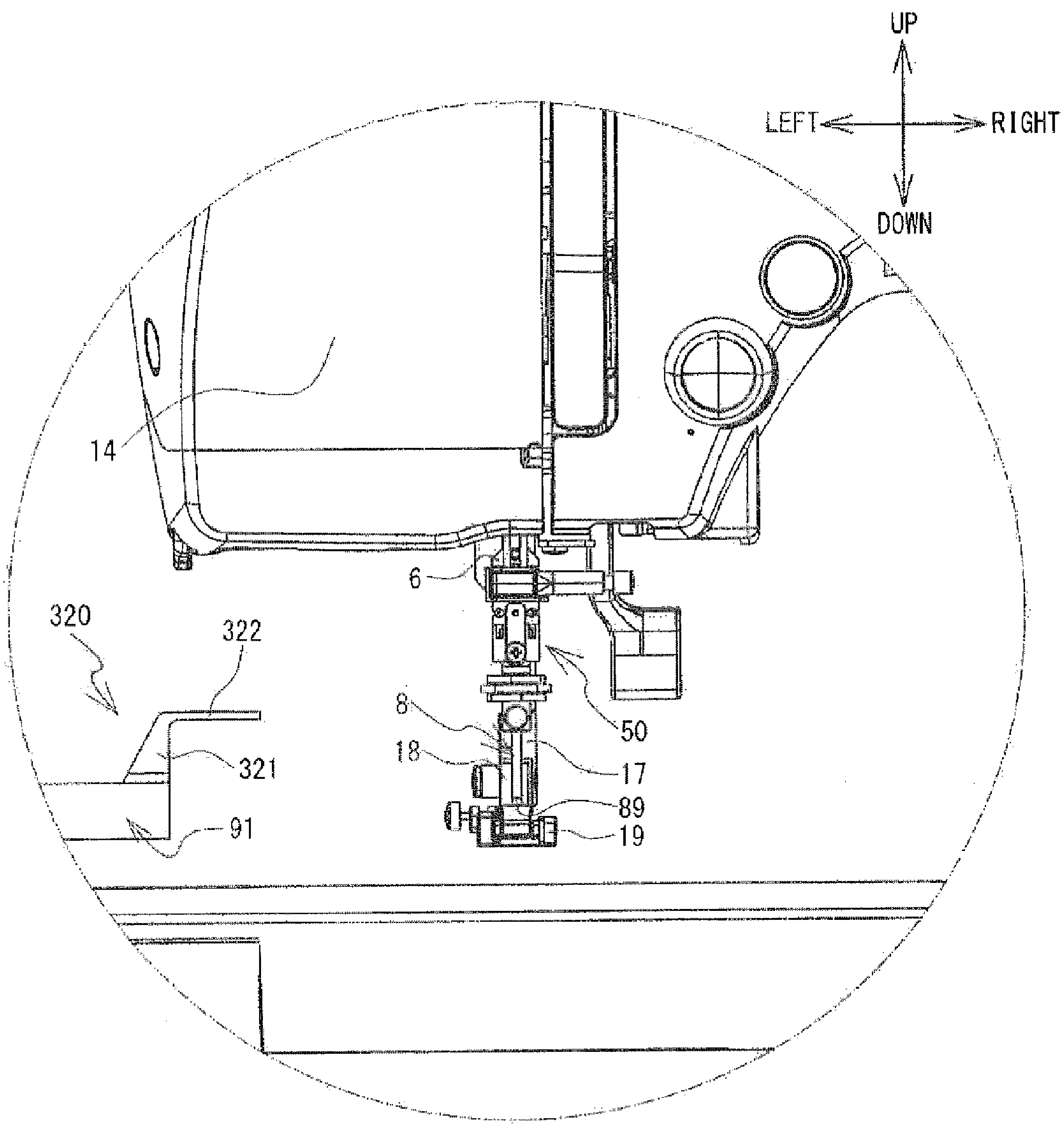


FIG. 4

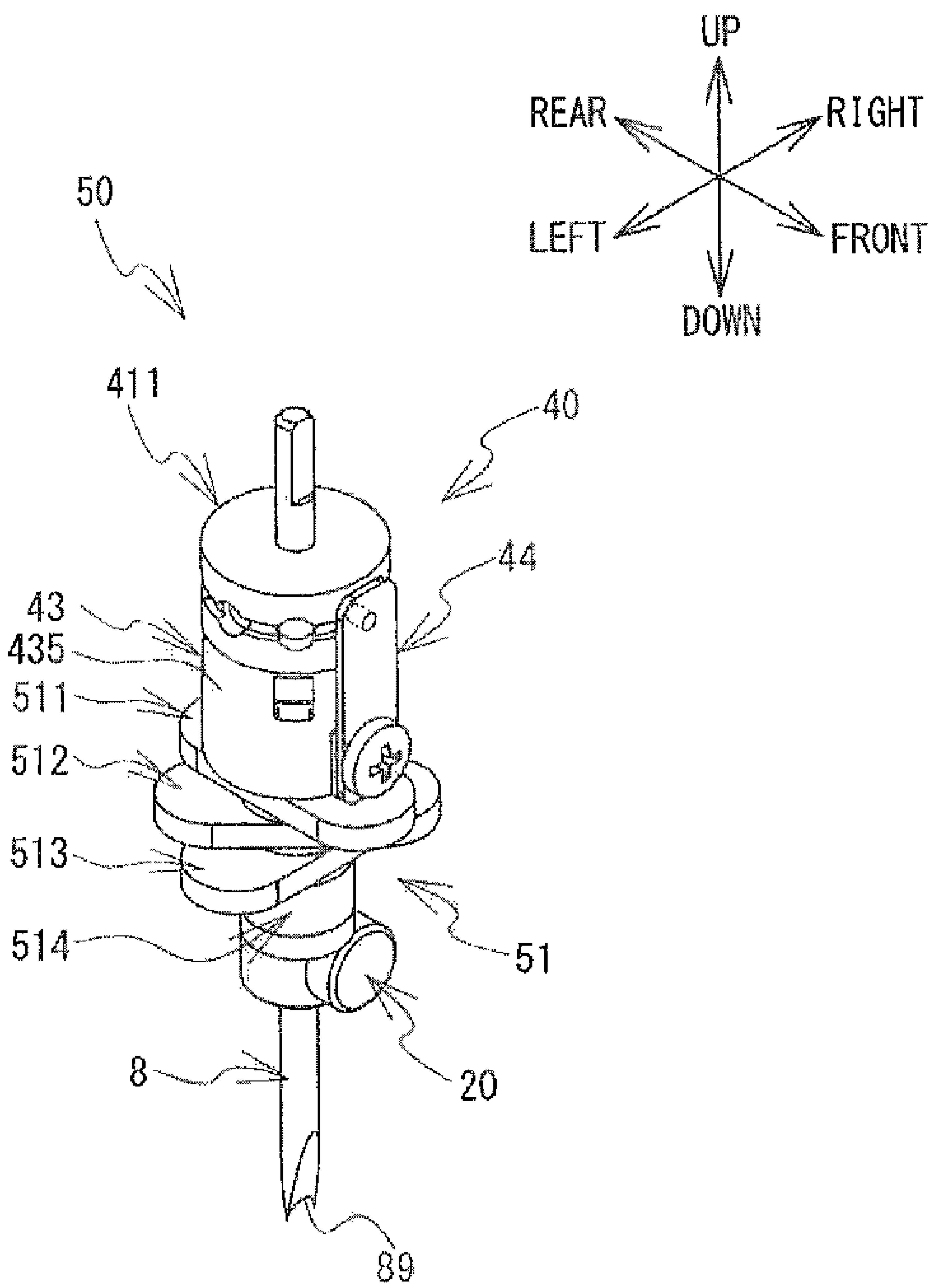
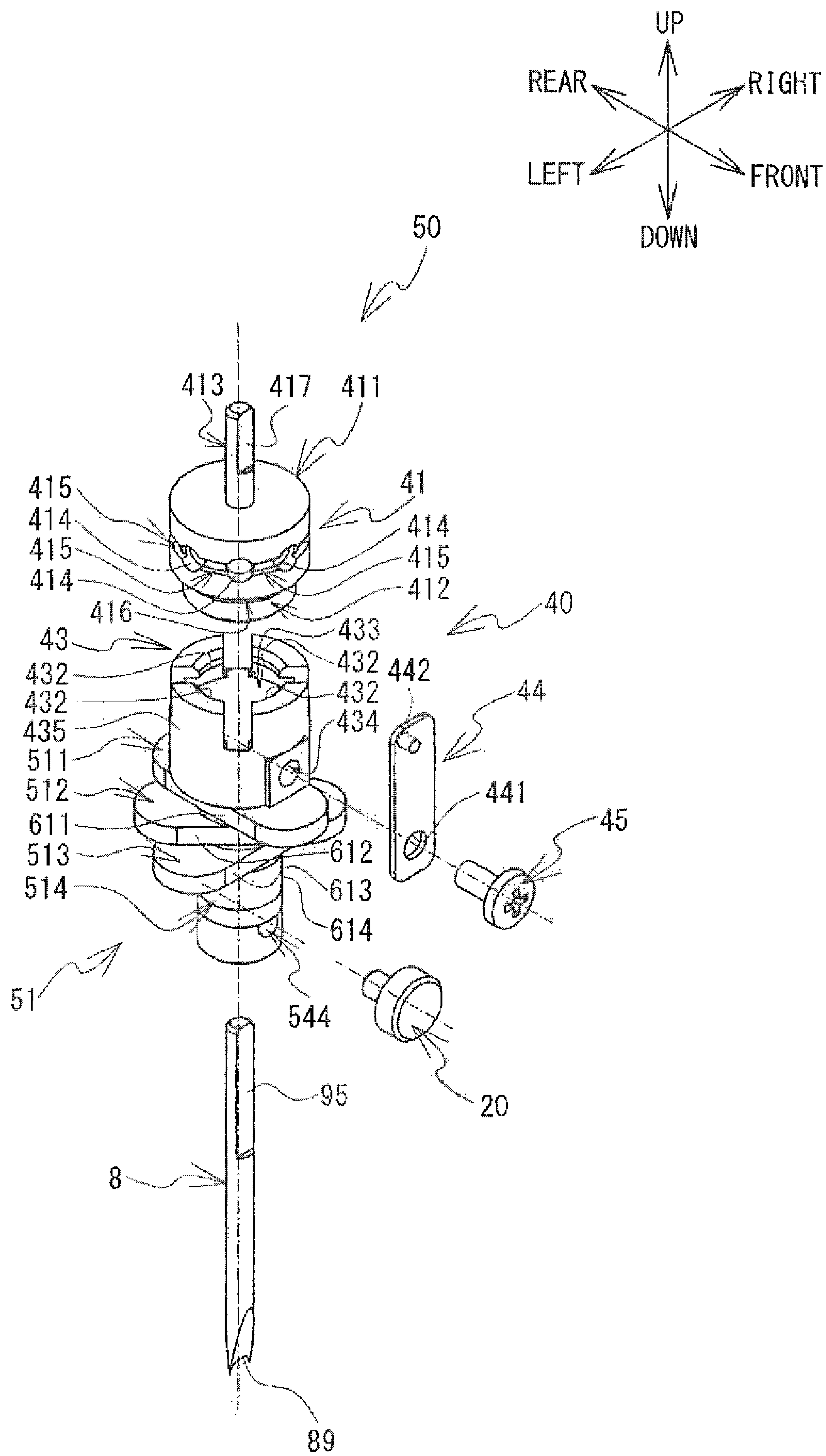

UP
REAR
RIGHT
LEFT
FRONT
DOWN
50
411
40
44
43
435
511
512
513
514
51
8
20
89

FIG. 5


UP
REAR
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FRONT
DOWN
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413
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411
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433
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43
432
432
432
432
442
435
434
44
511
512
441
611
45
612
513
613
514
614
51
544
20
95
8
89

FIG. 6

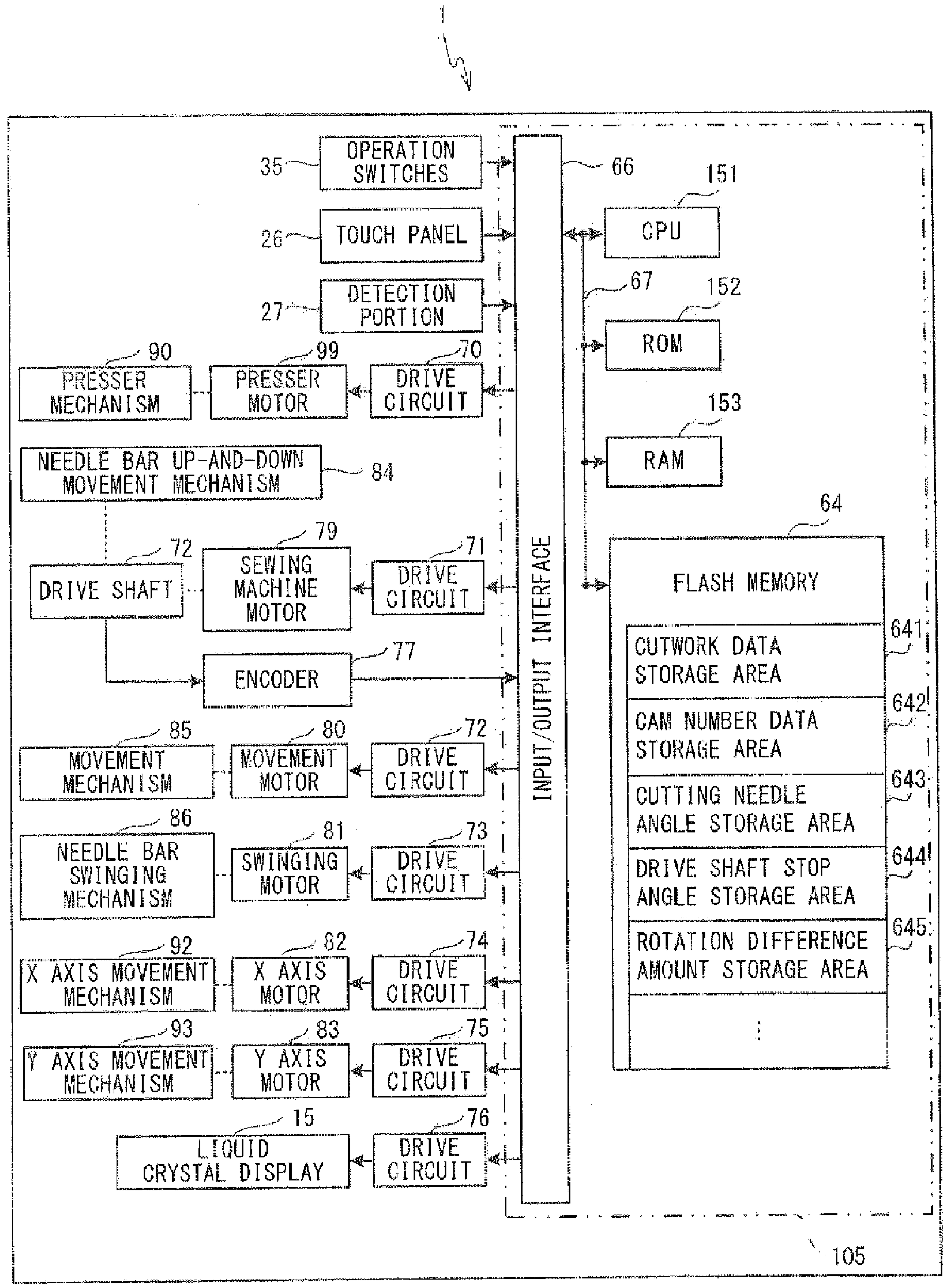

1
OPERATION SWITCHES
35
TOUCH PANEL
26
DETECTION PORTION
27
66
CPU
151
67
ROM
152
RAM
153
PRESSER MECHANISM
90
PRESSER MOTOR
99
DRIVE CIRCUIT
70
NEEDLE BAR UP-AND-DOWN MOVEMENT MECHANISM
84
DRIVE SHAFT
72
SEWING MACHINE MOTOR
79
DRIVE CIRCUIT
71
ENCODER
77
INPUT/OUTPUT INTERFACE
64
FLASH MEMORY
CUTWORK DATA STORAGE AREA
641
CAM NUMBER DATA STORAGE AREA
642
CUTTING NEEDLE ANGLE STORAGE AREA
643
DRIVE SHAFT STOP ANGLE STORAGE AREA
644
ROTATION DIFFERENCE AMOUNT STORAGE AREA
645
MOVEMENT MECHANISM
85
MOVEMENT MOTOR
80
DRIVE CIRCUIT
72
NEEDLE BAR SWINGING MECHANISM
86
SWINGING MOTOR
81
DRIVE CIRCUIT
73
X AXIS MOVEMENT MECHANISM
92
X AXIS MOTOR
82
DRIVE CIRCUIT
74
Y AXIS MOVEMENT MECHANISM
93
Y AXIS MOTOR
83
DRIVE CIRCUIT
75
LIQUID CRYSTAL DISPLAY
15
DRIVE CIRCUIT
76
105

FIG. 7

100

NEEDLE DROP NUMBER N	X COORDINATE DATA	Y COORDINATE DATA	CUTTING NEEDLE ANGLE DATA (DEGREES)
1	x1	y1	0
2	x2	y2	45
3	x3	y3	135
4	x4	y4	90
·	·	·	·
·	·	·	·
·	·	·	·
CUT_END	x	y	0

FIG. 8

210

CUTTING NEEDLE ANGLE DIFFERENCE DATA (DEGREES)	CURRENT CUTTING NEEDLE ANGLE 0 DEGREES			CURRENT CUTTING NEEDLE ANGLE 45 DEGREES			CURRENT CUTTING NEEDLE ANGLE 90 DEGREES			CURRENT CUTTING NEEDLE ANGLE 135 DEGREES		
	P=1	P=2	P=3	P=1	P=2	P=3	P=1	P=2	P=3	P=1	P=2	P=3
45	2	–	–	1	–	–	4	–	–	3	–	–
90	2	1	–	1	4	–	4	3	–	3	2	–
135	2	1	4	1	4	3	4	3	2	3	2	1

FIG. 9

220

CAM NUMBER M	DRIVE SHAFT STOP ANGLE DATA
1	A1
2	A2
3	A3
4	A4

FIG. 10

230

		CURRENT CAM NUMBER M			
		1	2	3	4
CAM NUMBER M FOR NEXT CONTACT	1	–	A21	A31	A41
	2	A12	–	A32	A42
	3	A13	A23	–	A43
	4	A14	A24	A34	–

FIG. 11

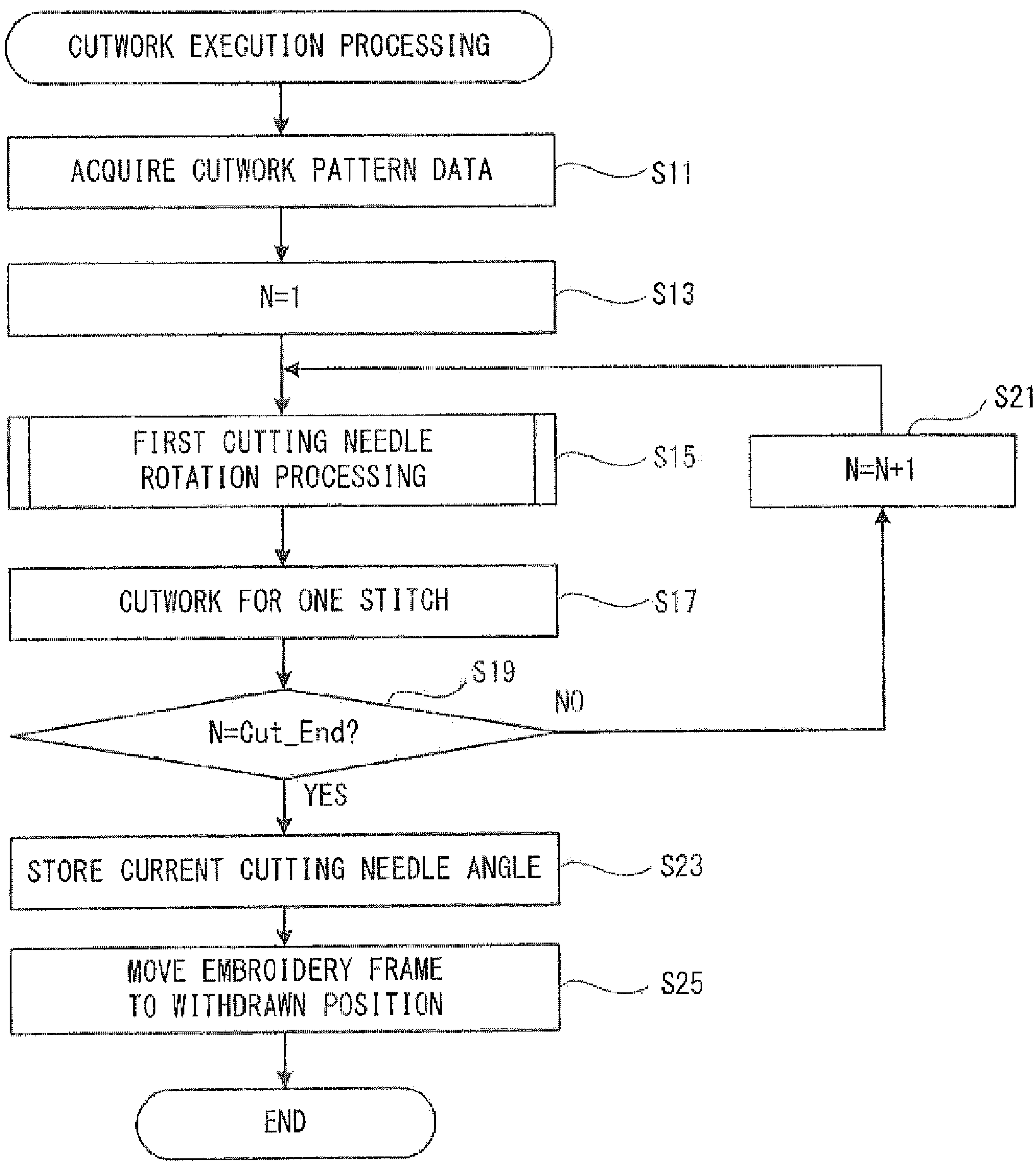
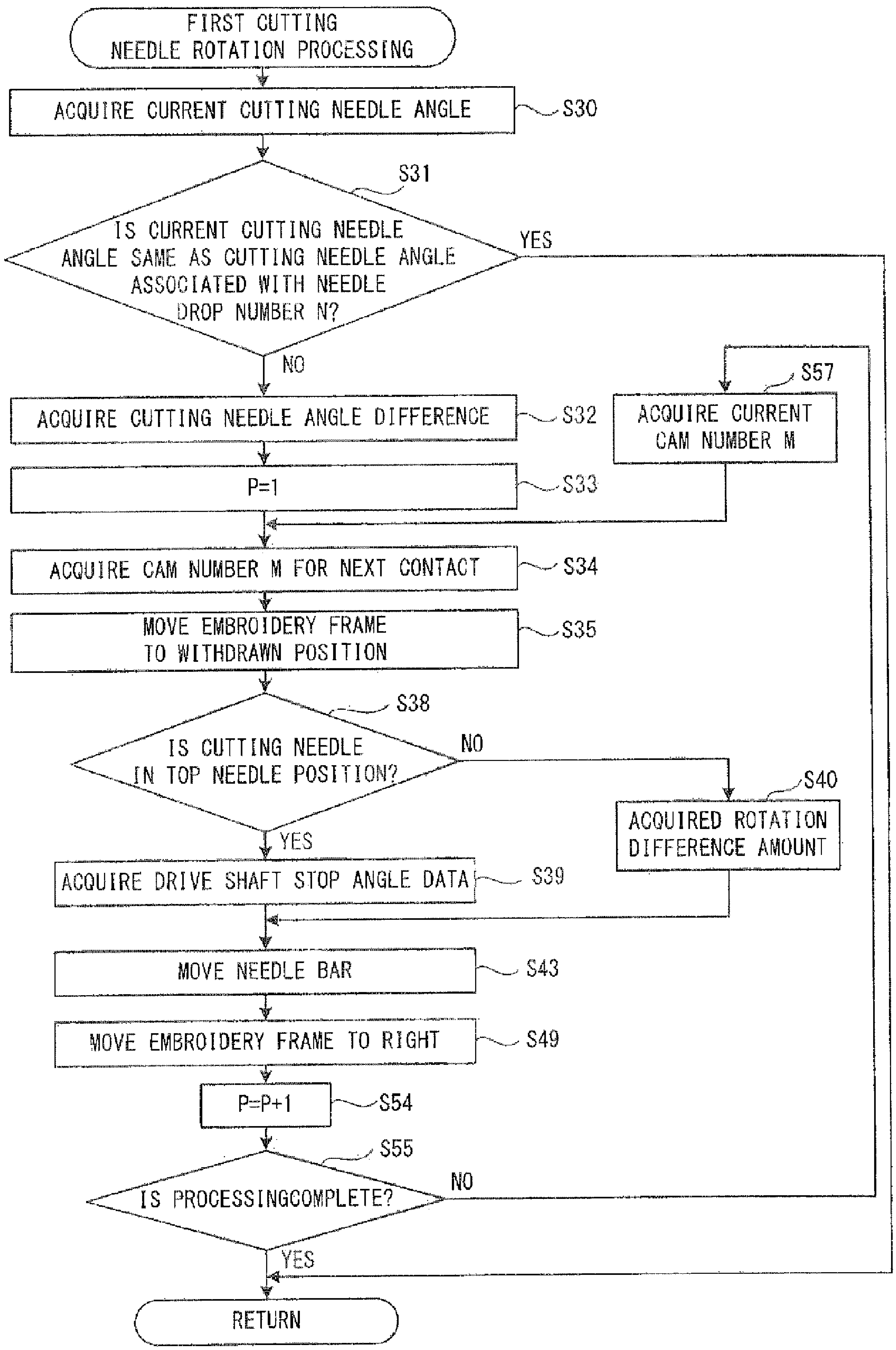
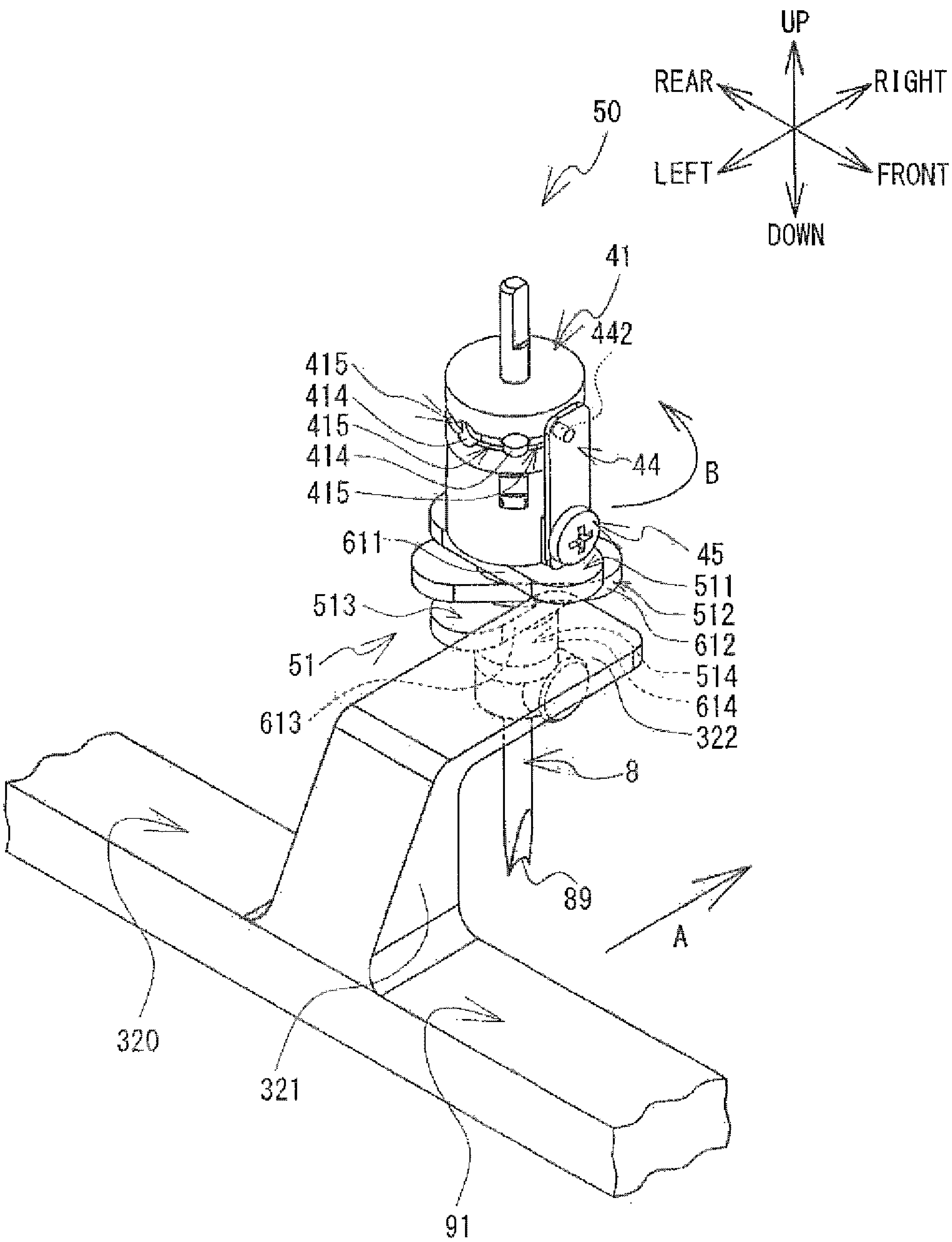

CUTWORK EXECUTION PROCESSING
ACQUIRE CUTWORK PATTERN DATA
S11
N=1
S13
FIRST CUTTING NEEDLE ROTATION PROCESSING
S15
S21
N=N+1
CUTWORK FOR ONE STITCH
S17
S19
NO
N=Cut_End?
YES
STORE CURRENT CUTTING NEEDLE ANGLE
S23
MOVE EMBROIDERY FRAME TO WITHDRAWN POSITION
S25
END

FIG. 12



FIRST CUTTING NEEDLE ROTATION PROCESSING
ACQUIRE CURRENT CUTTING NEEDLE ANGLE
S30
S31
IS CURRENT CUTTING NEEDLE ANGLE SAME AS CUTTING NEEDLE ANGLE ASSOCIATED WITH NEEDLE DROP NUMBER N?
YES
NO
ACQUIRE CUTTING NEEDLE ANGLE DIFFERENCE
S32
S57
ACQUIRE CURRENT CAM NUMBER M
P=1
S33
ACQUIRE CAM NUMBER M FOR NEXT CONTACT
S34
MOVE EMBROIDERY FRAME TO WITHDRAWN POSITION
S35
S38
IS CUTTING NEEDLE IN TOP NEEDLE POSITION?
NO
S40
ACQUIRED ROTATION DIFFERENCE AMOUNT
YES
ACQUIRE DRIVE SHAFT STOP ANGLE DATA
S39
MOVE NEEDLE BAR
S43
MOVE EMBROIDERY FRAME TO RIGHT
S49
P=P+1
S54
S55
IS PROCESSINGCOMPLETE?
NO
YES
RETURN

FIG. 13



UP
REAR
RIGHT
LEFT
FRONT
DOWN
50
41
442
415
414
415
414
415
44
B
45
611
511
512
513
612
51
514
613
614
322
8
89
A
320
321
91

FIG. 14

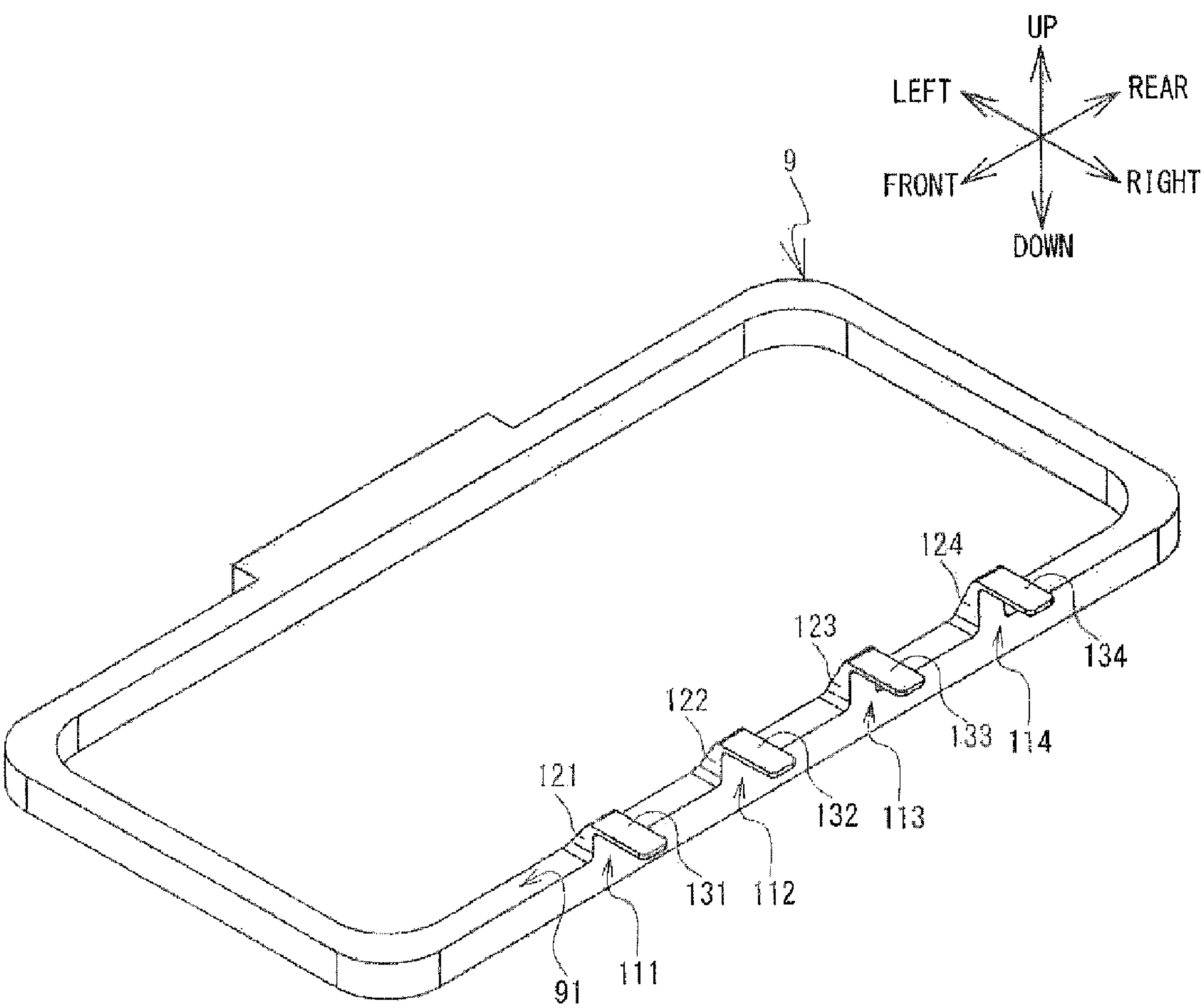

UP
LEFT
REAR
FRONT
RIGHT
DOWN
9
124
123
134
122
133
114
121
132
113
131
112
91
111

FIG. 15

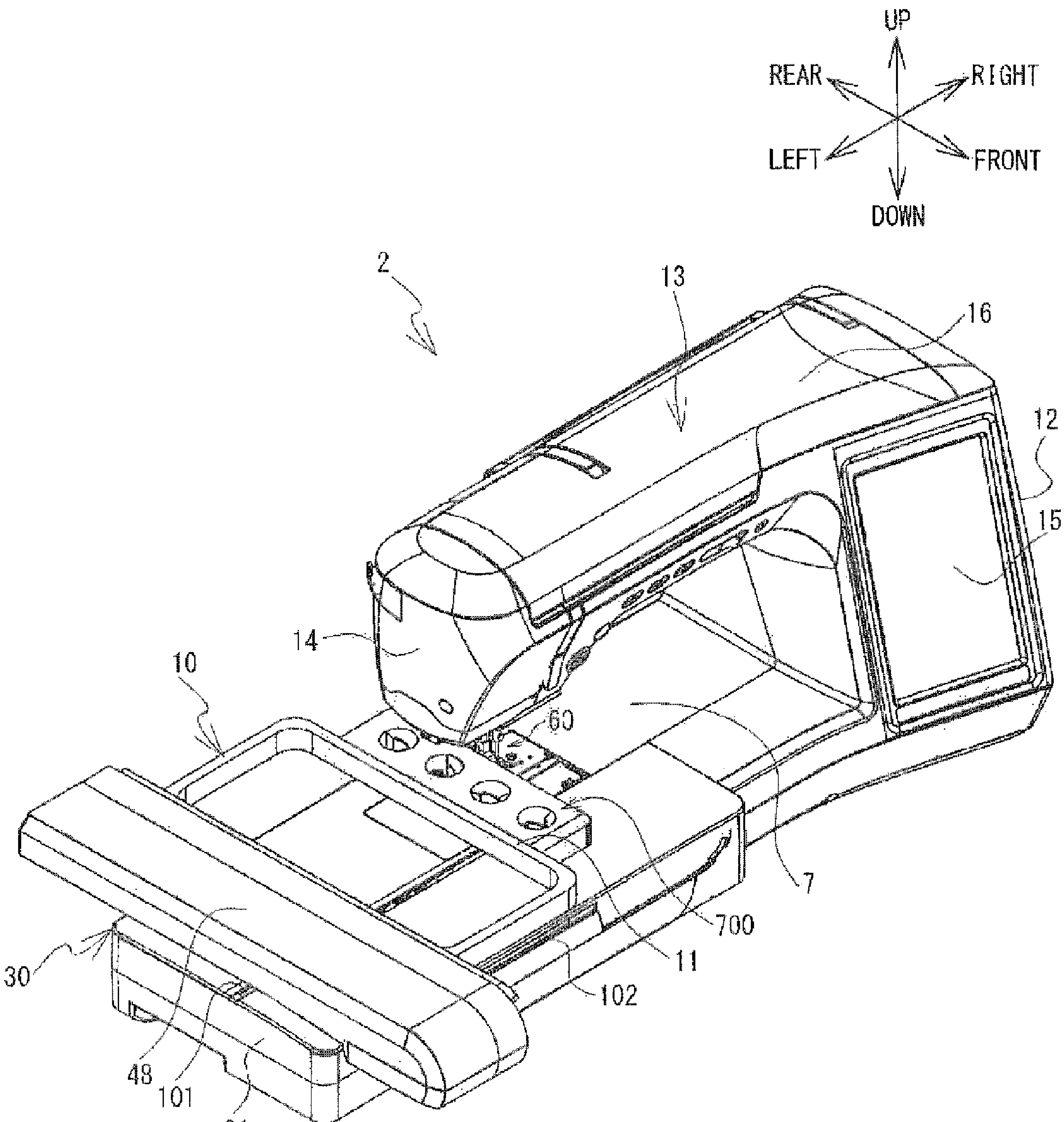
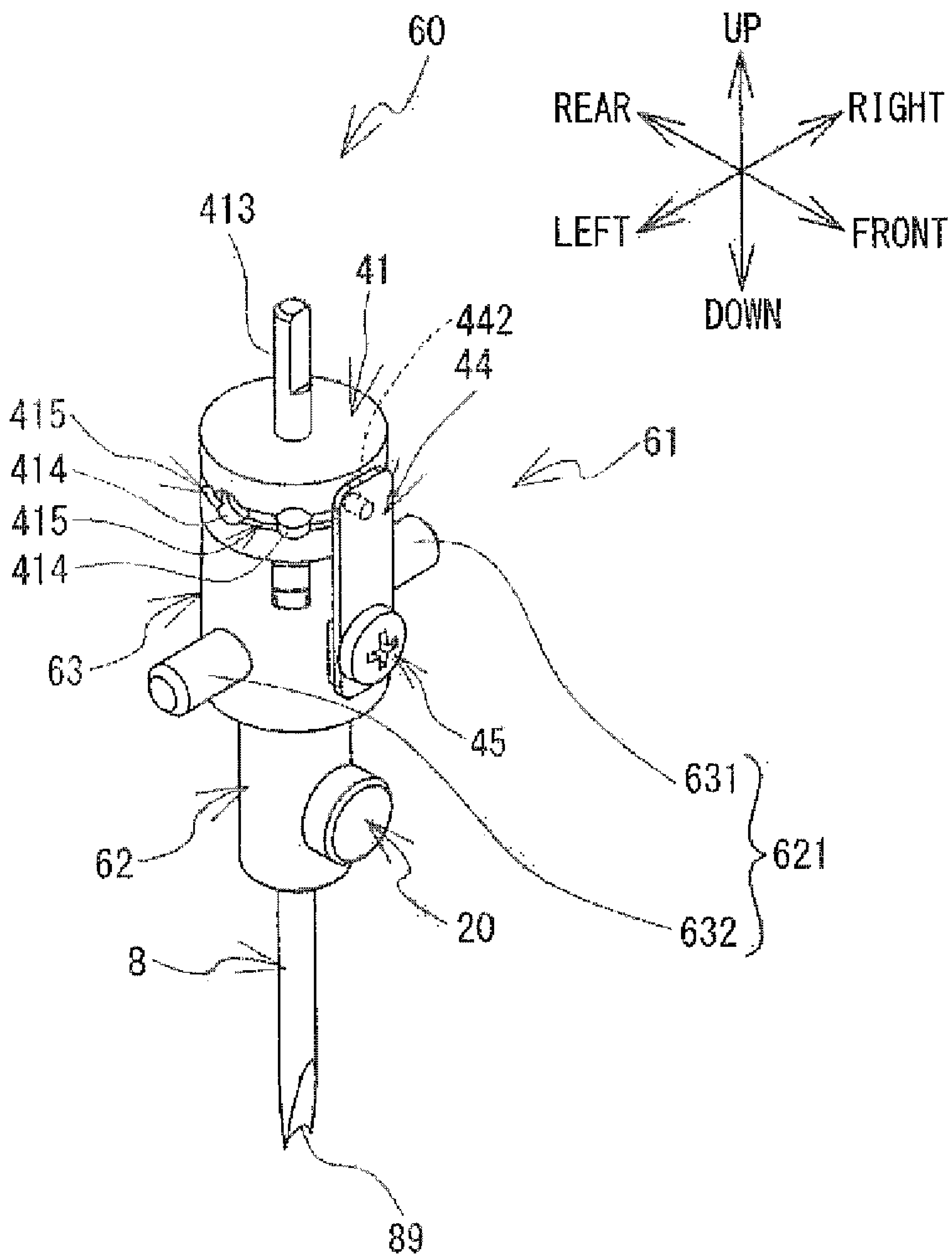

UP
REAR
RIGHT
LEFT
FRONT
DOWN
2
13
16
12
15
14
10
60
7
700
11
102
30
48
101
21

FIG. 16



60
UP
REAR
RIGHT
LEFT
FRONT
DOWN
413
41
442
44
415
414
415
414
61
63
45
631
621
62
632
20
8
89

FIG. 17

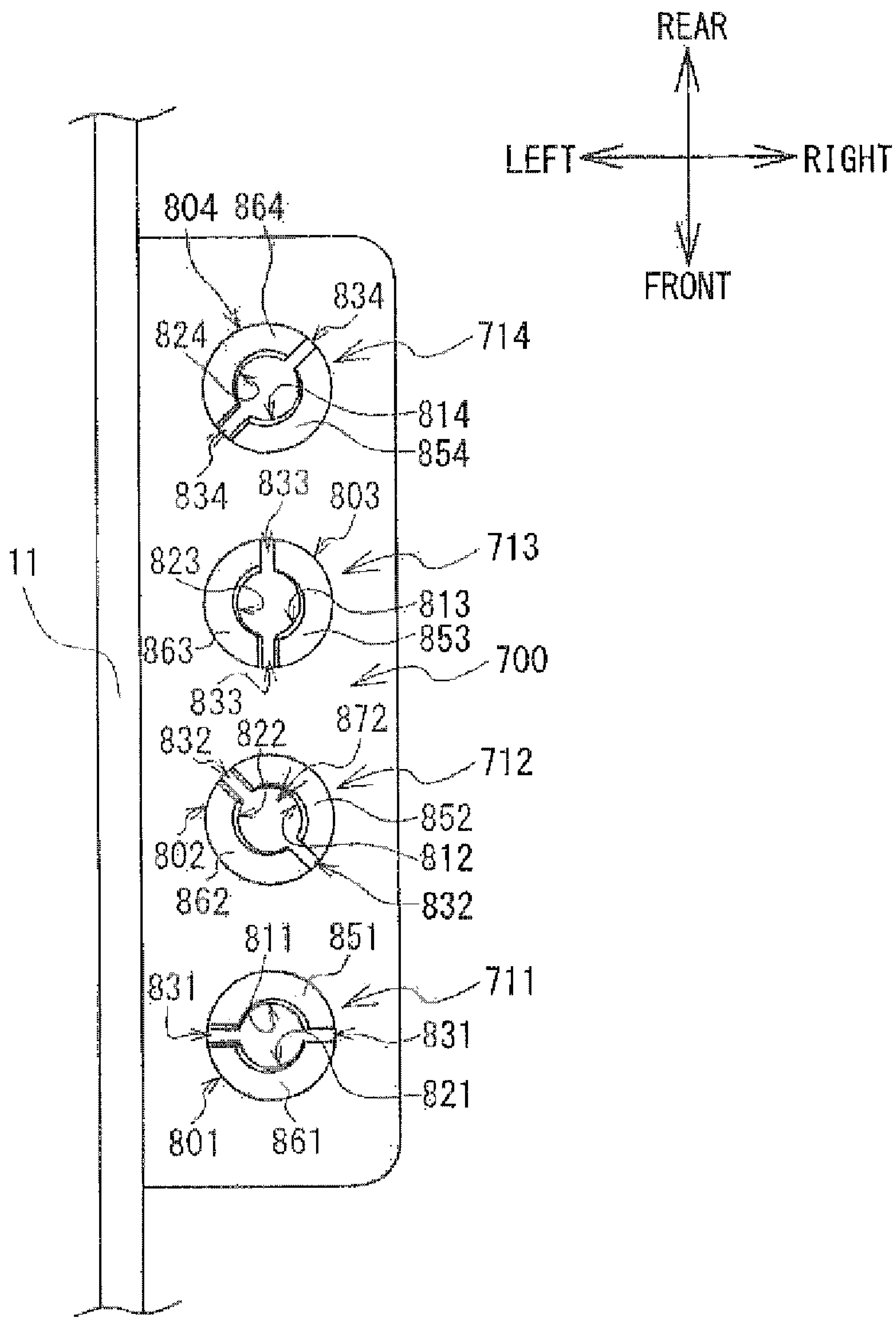

REAR
LEFT
RIGHT
FRONT
804
864
834
824
714
814
854
834
833
803
823
713
813
853
11
863
700
833
872
832
822
712
852
812
802
832
862
811
851
711
831
831
821
801
861

FIG. 18

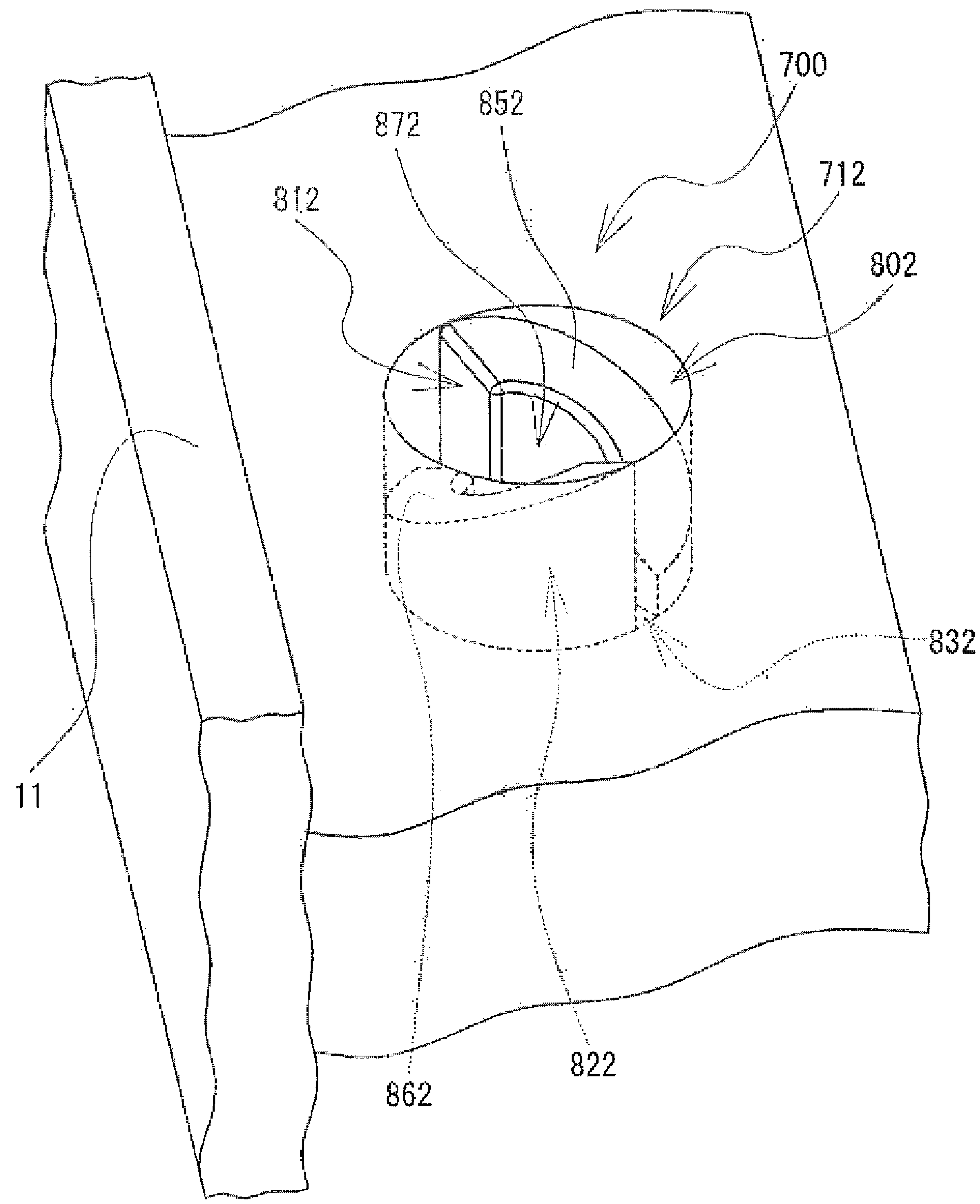


FIG. 19

300

CUTTING NEEDLE ANGLE DATA (DEGREES)	GUIDE PORTION NUMBER K	X COORDINATE DATA	Y COORDINATE DATA
0	1	u1	v1
45	2	u2	v2
90	3	u3	v3
135	4	u4	v4

FIG. 20

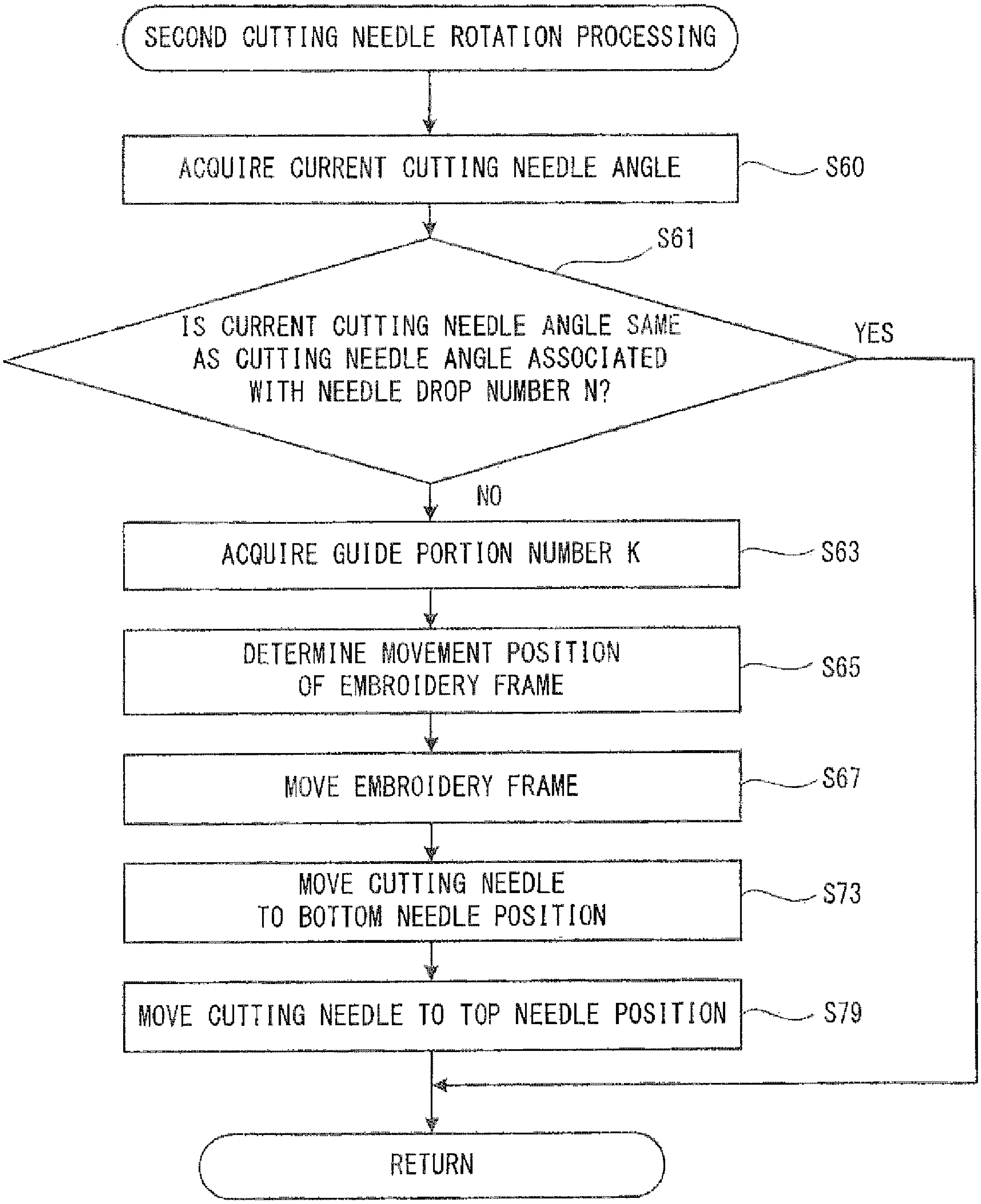
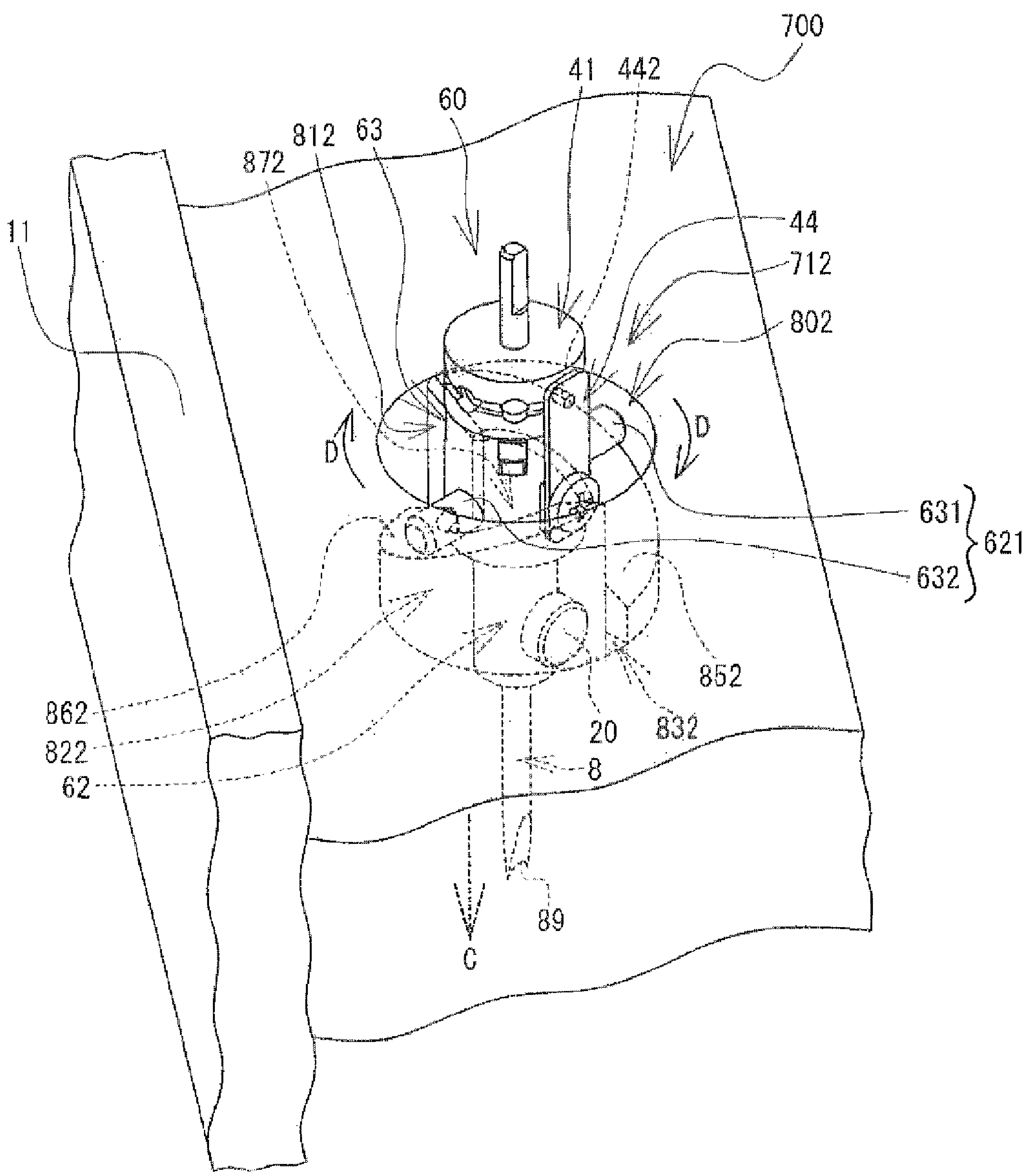

SECOND CUTTING NEEDLE ROTATION PROCESSING
ACQUIRE CURRENT CUTTING NEEDLE ANGLE
S60
S61
IS CURRENT CUTTING NEEDLE ANGLE SAME AS CUTTING NEEDLE ANGLE ASSOCIATED WITH NEEDLE DROP NUMBER N?
YES
NO
ACQUIRE GUIDE PORTION NUMBER K
S63
DETERMINE MOVEMENT POSITION OF EMBROIDERY FRAME
S65
MOVE EMBROIDERY FRAME
S67
MOVE CUTTING NEEDLE TO BOTTOM NEEDLE POSITION
S73
MOVE CUTTING NEEDLE TO TOP NEEDLE POSITION
S79
RETURN

FIG. 21



700
41
442
60
812
63
872
11
44
712
802
D
D
631
621
632
852
862
822
62
20
832
8
89
C

SEWING MACHINE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to Japanese Patent Application No. 2013-069182, filed on Mar. 28, 2013, the content of which is hereby incorporated by reference.

BACKGROUND

The present disclosure relates to a sewing machine.

A sewing machine is known that causes a cutting needle attached to a needle bar to automatically rotate. The sewing machine includes a rotation mechanism, which is provided on the cutting needle attached to the needle bar, and a presser bar. The presser bar includes a concave portion that is indented toward an axial line of the presser bar. The rotation mechanism includes a plurality of convex portions that are arranged at equal intervals along the direction of rotation of the cutting needle and that protrude in a direction in which they become separated from the cutting needle. The cutting needle and the plurality of convex portions rotate integrally. The rotation mechanism includes a rotation locking member that locks the rotation of the cutting needle. The rotation locking member locks one of the plurality of convex portions in a position in which it can engage with the concave portion.

When the sewing machine causes the cutting needle to rotate, the needle bar is lowered in a position in which one of the plurality of convex portions is in a position in which it can engage with the concave portion. After that, the sewing machine moves the needle bar in the horizontal direction. The convex portion that engages with the concave portion rotates around the axial line of the needle bar along with the movement of the needle bar. By this rotation, the sewing machine can automatically cause the cutting needle to rotate.

SUMMARY

However, with the above-described sewing machine, in an operation to cut a work cloth using the cutting needle by moving the needle bar up and down, it is necessary that the convex portion does not come into contact with the concave portion and a specific gap is provided between the convex portion and the concave portion. As a result, there is a possibility that the cutting needle may not rotate smoothly even if the needle bar is moved in the horizontal direction, due to variations in the dimensions of the above-described members and variations arising in the assembly of each of the members.

Various embodiments of the general principles described herein provide a sewing machine that each enable rotating a cutting needle stably and automatically.

Various embodiments herein provide a sewing machine that includes a needle bar driving mechanism, an embroidery frame movement mechanism, a cutting needle rotation mechanism, a processor, and a memory. The needle bar driving mechanism is configured to move a needle bar in a first direction. The embroidery frame movement mechanism is configured to receive an embroidery frame, and is configured to move the embroidery frame along a second direction crossing the first direction. The embroidery frame comprises a protruding portion that protrudes outward from the embroidery frame. The cutting needle rotation mechanism comprises a cutting needle, a cam member, and a support mechanism. The cam member has a fixed cutting needle and comprises a plurality of cams arranged along the first direction and rotatable around the first direction. Each of the plurality of cams comprises a surface portion. The surface portion comprises a width along the first direction and is arranged in different positions along the first direction. The support mechanism is configured to support the cam member on the needle bar rotatably. The memory is configured to store computer-readable instructions that cause the sewing machine to set a height of the needle bar to a specific position from a plurality of positions, each of the plurality of positions representing that each of the plurality of cams is able to contact with the protruding portion, instruct the needle bar driving mechanism to move the needle bar to the specific position, and instruct the embroidery frame movement mechanism to move the embroidery frame along the second direction to a predetermined position where the protruding portion is able to contact with one of the plurality of cams.

Embodiments also provide a sewing machine that includes a needle bar driving mechanism, an embroidery frame movement mechanism, a cutting needle rotation mechanism, a processor, and a memory. The needle bar driving mechanism is configured to move a needle bar in a first direction. The embroidery frame movement mechanism is configured to receive an embroidery frame and is configured to move the embroidery frame along a second direction and a third direction crossing the first direction. The embroidery frame comprises a plurality of protruding portions. Each of the plurality of the protruding portions is disposed on the embroidery frame along the third direction. Each of the plurality of the protruding portions protrudes outward from the embroidery frame. The cutting needle rotation mechanism comprises a cutting needle, a cam member, and a support mechanism. The cam member has a fixed cutting needle and comprises a plurality of cams arranged along the first direction and rotatable around the first direction. Each of the plurality of cams comprises a surface portion that comprises a width along the first direction and arranged in different positions along the first direction. The support mechanism is configured to support the cam member on the needle bar rotatably. The memory is configured to store computer-readable instruction that causes the sewing machine to instruct the embroidery frame movement mechanism to move the embroidery frame along the second direction and the third direction to a specific position where one of the plurality of protruding portions is able to contact with one of the plurality of cams.

Embodiments also provide a sewing machine that a needle bar driving mechanism, a cutting needle rotation mechanism, an embroidery frame movement mechanism, a processor, and a memory. The needle bar driving mechanism is configured to move a needle bar in a first direction. The cutting needle rotation mechanism comprises a cutting needle, a base member, and a support member. The base member comprises a protruding member that protrudes along a particular direction to be separated from the needle bar. The support member is configured to support the base member on the needle bar rotatably. The embroidery frame movement mechanism is configured to receive an embroidery frame and is configured to move the embroidery frame along a second direction crossing the first direction. The embroidery frame comprises a plurality of guide portions. Each of the plurality of guide portions is configured to engage with the protruding member. The memory is configured to store computer-readable instructions that cause the sewing machine to set a specific position of the embroidery frame to a predetermined position from a plurality of positions, each of the plurality of positions representing that each of the plurality of guide portions is able to engage with the protruding member, instruct the embroidery frame movement mechanism to move the embroidery frame to the specific position, and instruct the needle bar driving mechanism to move the needle bar in the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will be described below in detail with reference to the accompanying drawings in which:

FIG. **1** is an example of a perspective view of a sewing machine **1**;

FIG. **2** is an example of an enlarged perspective view of the vicinity of a cutting needle rotation mechanism **50**;

FIG. **3** is an example of an enlarged right side view of the vicinity of the cutting needle rotation mechanism **50**;

FIG. **4** is an example of a perspective view of the cutting needle rotation mechanism **50**;

FIG. **5** is an example of an exploded perspective view of the cutting needle rotation mechanism **50**;

FIG. **6** is an example of a block diagram showing an electrical configuration of the sewing machine **1**;

FIG. **7** is an example of a data configuration diagram of outwork pattern data **100**;

FIG. **8** is an example of a data configuration diagram of cam number data **210**;

FIG. **9** is an example of a data configuration diagram of drive shaft stop angle data **220**;

FIG. **10** is an example of a data configuration diagram of rotation difference amount data **230**;

FIG. **11** is an example of a flowchart of cutwork execution processing;

FIG. **12** is an example of a flowchart of first cutting needle rotation processing;

FIG. **13** is an example of a perspective view of a contact portion **322** causing a cam **512** to rotate;

FIG. **14** is an example of a perspective view showing a modified example of an embroidery frame **9**;

FIG. **15** is an example of a perspective view of a sewing machine **2**;

FIG. **16** is an example of a perspective view of a cutting needle rotation mechanism **60**;

FIG. **17** is an example of a plan view of a support portion **700**;

FIG. **18** is an example of a perspective view of a guide portion **712**;

FIG. **19** is an example of a data configuration diagram of guide portion number data **300**;

FIG. **20** is an example of a flowchart of second cutting needle rotation processing; and

FIG. **21** is an example of a perspective view of a case in which a protruding portion **621** is guided by the guide portion **712**.

DETAILED DESCRIPTION

Hereinafter, a sewing machine **1** according to a first embodiment of the present disclosure will be explained with reference to the drawings. The sewing machine **1** performs sewing or cut work on a work cloth (not shown in the drawings). The cut work is an operation to form a pattern on the work cloth by cutting out specific areas of the work cloth.

The configuration of the sewing machine **1** will be explained with reference to FIG. **1** to FIG. **3**. The lower right side, the upper left side, the lower left side, the upper right side, the upper side and the lower side in FIG. **1** correspond, respectively, to the front side, the rear side, the left side, the right side, the upper side and the lower side of the sewing machine **1**. Further, the left-right direction of the sewing machine **1** is an X direction and the front-rear direction of the sewing machine **1** is a Y direction.

As shown in FIG. **1**, the sewing machine **1** is provided with a bed portion **7**, a pillar **12**, an arm portion **13** and a head portion **14**. The bed portion **7** is a base of the sewing machine **1** and extends in the left-right direction. An embroidery frame movement mechanism **30**, which will be described later, can be detachably mounted on the bed portion **7**. The pillar **12** is provided extending upward from the right end portion of the bed portion **7**. The arm portion **13** extends to the left from the top end portion of the pillar **12**. The head portion **14** is provided on the leading left end of the arm portion **13**. A needle plate **5** is disposed on the top surface of the bed portion **7**. A feed dog (not shown in the drawings), a movement mechanism **85** (refer to FIG. **6**), a movement motor **80** (refer to FIG. **6**) and a shuttle mechanism (not shown in the drawings) are provided inside the bed portion **7** below the needle plate **5**. The feed dog moves the work cloth that is placed on the top of the bed portion **7** by a predetermined amount. The movement mechanism **85** drives the feed dog. The movement motor **80** is a pulse motor that drives the movement mechanism **85**. The shuttle mechanism is a mechanism that is structured to form stitches in a sewing workpiece, by moving in concert with a sewing needle, when the sewing needle (not shown in the drawings) is attached to the lower end of the needle bar **6** (which will be described later).

A vertically long rectangular liquid crystal display **15** is provided on the front surface of the pillar **12**. The liquid crystal display **15** displays images of various items, such as a plurality of types of sewing patterns or cutwork patterns, names of commands to execute various functions, and various messages etc. A transparent touch panel **26** (refer to FIG. **6**) is provided on the front surface of the liquid crystal display **15**. A user can select or input a desired sewing pattern, a desired cutwork patter or a command to be executed by touching a portion on the touch panel **26** that corresponds to an item displayed on the liquid crystal display **15**, using a finger or a dedicated touch pen.

The structure of the arm portion **13** will be explained. Operation switches **35**, which include a sewing start switch etc., are provided on the lower portion of the front surface of the arm portion **13**. An opening/closing cover **16** is provided on the upper portion of the arm portion **13**. FIG. **1** shows a state in which the opening/closing cover **16** is closed. The opening/closing cover **16** is axially supported by a rotating shaft (not shown in the drawings) that extends in the left-right direction. The rotating shaft is provided on the upper rear end portion of the arm portion **13**. A thread storage portion (not shown in the drawings) housing a thread spool (not shown in the drawings) that supplies an upper thread (not shown in the drawings) is provided underneath the opening/closing cover **16**, that is, inside the arm portion **13**. The upper thread that extends from the thread spool is supplied to a sewing needle that is not shown in the drawings, via a threading portion that includes a tensioner, a thread take-up spring and a thread take-up lever etc (that are not shown in the drawings). The tensioner is provided on the head portion **14** and adjusts the thread tension. The thread take-up lever is driven to move reciprocatingly in the up-down direction and pulls up the upper thread. A sewing needle (not shown in the drawings) or a cutting needle rotation mechanism **50** can be selectively attached to the lower end of the needle bar **6** (refer to FIG. **3**) that is provided on the lower portion of the head portion **14**. The sewing needle is attached when the sewing machine **1** performs the sewing operation, and the cutting needle rotation mechanism **50** is attached when the sewing machine **1** performs outwork. The needle bar **6** is driven to move in the up-down direction by a needle bar up-and-down movement mechanism **84** (refer to FIG. **6**) that is provided inside the head portion **14**. The needle bar up-and-down movement mechanism **84** is driven by a drive shaft **72** (refer to FIG. **6**) that is rotated by a sewing machine motor **79** (refer to FIG. **6**). When the drive shaft **72** makes one rotation, the needle bar **6** moves reciprocatingly once in the up-down direction. In other words, the rotation angle of the drive shaft **72** and the position (height) of the needle bar **6** in the up-down direction correspond to each other, and the position of the needle bar **6** in the up-down direction can be determined by detecting the rotation angle of the drive shaft **72**. Further, due to a needle bar swinging mechanism **86** (refer to FIG. **6**) that is provided inside the head portion **14**, the needle bar **6** can swing in a direction that is orthogonal to a direction (the front-rear direction) in which the work cloth is fed by the feed dog (not shown in the drawings). The needle bar swinging mechanism **86** is driven by a swinging motor **81** (refer to FIG. **6**).

As shown in FIG. **2** and FIG. **3**, the cutting needle rotation mechanism **50** is detachably attached to the lower end of the needle bar **6**. The cutting needle rotation mechanism **50** rotatably supports a cutting needle **8** that extends in the up-down direction. When the cutting needle rotation mechanism **50** is attached to the needle bar **6**, the needle bar **6** moves to a position that is highest in a movement range of the needle bar **6** in the up-down direction (hereinafter also referred to as a top needle position). When the cutting needle **8** is used to perform cutwork, a blade portion **89** of the cutting needle **8** is moved from the top side to the bottom side of the work cloth (not shown in the drawings) and forms a specific cut in the work cloth that depends on the orientation of the blade portion **89**. The cutting needle rotation mechanism **50** will be explained in more detail later.

A presser bar **17** (refer to FIG. **3**) is provided to the rear of the needle bar **6**. A presser mechanism **90** (refer to FIG. **6**) that is provided inside the head portion **14** is driven by a presser motor **99** (refer to FIG. **6**), and the presser bar **17** is thus moved up and down. A presser holder **18** is attached to the lower end of the presser bar **17**. A presser foot **19**, which presses the work cloth, is detachably mounted on the presser holder **18**.

As shown in FIG. **1**, the embroidery frame movement mechanism **30** includes a main body case **21** that has a flat top surface and a movable case **48** that is disposed on the top side of the main body case **21**. A slit **101** that extends in the left-right direction is provided in a central portion, in the front-rear direction, of the top surface of the main body case **21**. A slit **102** that extends in the left-right direction is provided in the top portion of the front surface of the main body case **21**.

The movable case **48** has a cuboid shape that is longer in the front-rear direction. The movable case **48** is provided internally with a frame holder (not shown in the drawings), a Y axis movement mechanism **93** (refer to FIG. **6**) and a Y axis motor **83** (refer to FIG. **6**). A part of the frame holder is exposed from the movable case **48** and an embroidery frame **9** can be detachably mounted on the frame holder. The embroidery frame **9** holds the work cloth. The work cloth held by the embroidery frame **9** is placed on the top of the bed portion **7** and below the needle bar **6** (refer to FIG. **3**) and the presser foot **19** (refer to FIG. **2**). The embroidery frame **9** will be explained in more detail later. The Y axis movement mechanism **93** is a mechanism that moves the frame holder in the front-rear direction (the Y direction). The embroidery frame **9** that holds the work cloth moves in the front-rear direction by the frame holder being moved in the front-rear direction. The Y axis motor **83** drives the Y axis movement mechanism **93**.

The main body case **21** is provided internally with an X axis movement mechanism **92** (refer to FIG. **6**) and an X axis motor **82** (refer to FIG. **6**). The X axis movement mechanism **92** moves the movable case **48** in the left-right direction (the X direction). A support portion (not shown in the drawings) that supports the movable case **48** passes through each of the slits **101** and **102** and is coupled to the X axis movement mechanism **92**. The embroidery frame **9** that holds the work cloth moves in the left-right direction by the movable case **48** being moved in the left-right direction. The X axis motor **82** drives the X axis movement mechanism **92**.

The structure of the cutting needle rotation mechanism **50** will be explained with reference to FIG. **4** and FIG. **5**. As shown in FIG. **4**, the cutting needle rotation mechanism **50** includes a support mechanism **40**, a cam member **51** and the cutting needle **8**. The support mechanism **40** is attached to the lower end of the needle bar **6** (refer to FIG. **3**). The support mechanism **40** supports the cam member **51** such that the cam member **51** can rotate around the axial line of the needle bar **6**. Further, the upper end of the cutting needle **8** is fixed to the lower end of the cam member **51**. The axial line of the cutting needle **8** is aligned with the axial line of the needle bar **6** (refer to FIG. **3**).

As shown in FIG. **5**, the support mechanism **40** includes a support member **41**, a rotation member **43** and a plate spring **44**. The support member **41** is formed of a synthetic resin material and is a substantially cylindrical shape that extends in the up-down direction. The axial line of the support member **41** is aligned with the axial line of the cutting needle **8**. The support member **41** includes a first support portion **411** and a second support portion **412**. The second support portion **412** extends downward from the lower end of the first support portion **411**. The outer diameter of the second support portion **412** is smaller than the outer diameter of the first support portion **411**. The first support portion **411** has a spindle **413**, engagement receiving portions **414** and a groove portion **415**. The spindle **413** is a shaft that extends upward from a central portion of the upper end surface of the first support portion **411**. The spindle **413** is a metal shaft and is fixed to the first support portion **411** such that the spindle **413** cannot rotate. The axial line of the spindle **413** is aligned with the axial line of the support member **41**. The upper end of the spindle **413** is attached to the needle bar **6** (refer to FIG. **3**). A flat surface portion **417** is formed on the spindle **413** and the spindle **413** is attached to the needle bar **6** such that the flat surface portion **417** is parallel to a specific direction (the left-right direction in FIG. **5**). With the above-described structure, the cutting needle rotation mechanism **50** is attached to the needle bar **6** with a specific orientation. The engagement receiving portions **414** are circular holes that are provided in an outer peripheral portion of the first support portion **411**. The eight engagement receiving portions **414** are arranged every 45 degrees in a plan view, in the circumferential direction of the outer peripheral portion. The groove portion **415** is formed along the outer peripheral portion of the first support portion **411** and is a groove portion that joins the mutually adjacent engagement receiving portions **414**. The second support portion **412** has a concave portion **416**. The concave portion **416** is formed on the top end of the second support portion **412**, in the circumferential direction of an outer peripheral portion.

The rotation member **43** is made of a synthetic resin and is a substantially cylindrical shape that extends in the up-down direction. The axial line of the rotation member **43** is aligned with the axial line of the support member **41**. An insertion hole **433** is formed in the upper end of the rotation member **43**. The insertion hole **433** is a hole that is substantially circular in a plan view and that extends downward from the top end surface of the rotation member **43**. The inner diameter of the insertion hole **433** is slightly larger than the outer diameter of the second support portion **412**. The second support portion **412** is inserted into the insertion hole **433**. The insertion hole **433** is surrounded by an outer peripheral portion **435** of the rotation member **43**. Four cut-out portions, which are cut out from the top toward the bottom, are arranged on the top end of the outer peripheral portion **435**, each of the cut-out portions being arranged at equal intervals along the circumferential direction of the outer peripheral portion **435**. The top end of the outer peripheral portion **435** is divided up by the four cut-out portions and each of the divided portions has a convex portion **432** that protrudes toward the inner side. The top end of the outer peripheral portion **435** can be elastically deformed in the radial direction. Each of the convex portions **432** fits with the concave portion **416**. The inner dimension of each of the four convex portions **432** is slightly smaller than the outer diameter of the lower end of the second support portion **412**, and slightly larger than the outer diameter of the outer peripheral portion of the portion of the second support portion **412** on which the concave portion **416** is formed. Here, when the rotation member **43** is assembled on the support member **41**, the second support portion **412** is inserted into the insertion hole **433**. At the time of insertion, the top end of the outer peripheral portion **435** deforms elastically and spreads to the outer side, and the convex portions **432** pass the lower portion of the second support portion **412**. After that, when a position is reached in which each of the convex portions **432** fits with the concave portion **416**, the divided portions of the top end of the outer peripheral portion **435** that were elastically deformed each return to their original shape. As described above, the movement of the rotation member **43** in the up-down direction is locked by the so-called snap fit of the convex portions **432** in the concave portion **416**, and the rotation member **43** is then able to rotate around the axial line. With the above-described structure, the rotation member **43** is rotatably supported by the support member **41**.

The plate spring **44** is a thin plate-shaped elastic member having a rectangular shape that is long in the up-down direction. A hole **441** is formed on the lower side (a base end side) of the plate spring **44**. The hole **441** is aligned with the position of a screw hole **434** that is formed in the rotation member **43**, and the plate spring **44** is fixed to the rotation member **43** by being fixed by a screw **45**. An engagement portion **442** is formed on the upper side (a leading end side) of the plate spring **44**. The engagement portion **442** is a convex portion that protrudes from the leading end of the plate spring **44** toward the axial line of the rotation member **43** (to the rear in FIG. **5**). The engagement portion **442** engages with one of the eight engagement receiving portions **414**.

The plate spring **44** imparts an urging force in a direction in which the engagement portion **442** engages with the engagement receiving portion **414** (a direction toward the axial line of the support member **41**). As a result, the rotation of the rotation member **43** (to which the plate spring **44** is fixed) around its axial line is locked with respect to the support member **41**.

The cam member **51** is a member that extends downward from a central portion of the lower end surface of the rotation member **43**. The cam member **51** rotates integrally with the rotation member **43**. The axial line of the cam member **51** is aligned with the axial line of the rotation member **43**. The cam member **51** has cams **511** to **514** and a shaft hole (not shown in the drawings).

Each of the cams **511** to **514** is substantially elliptical in a plan view, each having a width in the up-down direction and each having mutually the same shape. The cams **511** to **514** are formed integrally such that they overlap with one another in the up-down direction. The centers of the cams **511** to **514** are all positioned on the axial line of the cam member **51**.

In a rotation direction that is centered on the axial line of the cam member **51**, the longitudinal direction of each of the cams **511** to **514** is displaced by 45 degrees, in a plan view, with respect to the mutually adjacent cam. When the left-right direction is taken as reference and the counter-clockwise direction is taken as a positive direction in the plan view, all the angles in the longitudinal direction of each of the cams **511** to **514** (hereinafter referred to as the "longitudinal direction angle") are different. In FIG. **4** and FIG. **5**, the longitudinal direction angle of the cam **511** is 90 degrees, the longitudinal direction angle of the cam **512** is 135 degrees, the longitudinal direction angle of the cam **513** is zero degrees and the longitudinal direction angle of the cam **514** is 45 degrees. The cams **511** to **514** rotate integrally. In first cutting needle rotation processing that will be described later, the cams **511** to **514** rotate in the clockwise direction in the plan view and the longitudinal direction angle of each of the cams **511** to **514** thus changes every 45 degrees.

The cam **511** is provided with a contact receiving portion **611**. Similarly, the cam **512** is provided with a contact receiving portion **612**, the cam **513** is provided with a contact receiving portion **613** and the cam **514** is provided with a contact receiving portion **614**. Each of the contact receiving portions **611** to **614** is formed of a pair of side wall portions that are symmetric with respect to the axial line of each of the cams **511** to **514**. Each of the contact receiving portions **611** to **614** extends in the longitudinal direction of each of the cams **511** to **514**. That is, the longitudinal direction of each of the contact receiving portions **611** to **614** is displaced by 45 degrees with respect to the adjacent one of the contact receiving portions **611** to **614**, in the rotational direction around the axial line of the cam member **51**. As will be described later, a contact portion **322** that is provided on the embroidery frame **9** comes into contact with one of the contact receiving portions **611** to **614**.

The shaft hole (not shown in the drawings) is formed in a substantially D shape in a bottom view and extends upward from the bottom end surface of the cam member **51**. As will be described later, the top end of the cutting needle **8** is inserted into the shaft hole. A screw hole **544** is provided in the lower end of the outer peripheral wall of the cam member **51** and communicates with the shaft hole.

The cutting needle **8** extends in the up-down direction and the lower end of the cutting needle **8** has the blade portion **89** that cuts out the work cloth. The blade portion **89** has a width in a direction that is orthogonal to the axial line of the cutting needle **8**. The upper end of the cutting needle **8** has a substantially D shape in a plan view and is provided with a flat surface portion **95** that extends in parallel with the axial direction. The upper end of the cutting needle **8** is inserted into the shaft hole of the cam member **51** and is fixed to the cam member **51** in a state in which the flat surface portion **95** is pressed by the leading end of a screw **20** that is screwed into the screw hole **544**. With the above-described structure, the cutting needle **8** rotates integrally with the cam member **51**. The direction in which the blade portion **89** extends (hereinafter referred to as the width direction) is a specific direction (the left-right direction in FIG. **5**).

Next, the embroidery frame **9** will be explained with reference to FIG. **1** and FIG. **2**. The embroidery frame **9** has a known structure and is provided with an outer frame, an inner frame and an adjusting screw that is provided on the outer frame in order to adjust the size of the embroidery frame **9**. However, for convenience of explanation in the present embodiment, the inner frame and the adjusting screw are not illustrated in the drawings and only the outer frame is illustrated. The embroidery frame **9** is formed as a ring that is substantially rectangular in a plan view. On the embroidery frame **9**, a protruding portion **320** that protrudes upward is provided on a central portion, in the front-rear direction, of a right side portion of an outer frame **91**. The protruding portion **320** includes a support portion **321** and a contact portion **322**. The support portion **321** protrudes upward from the top surface of the central portion of the outer frame **91**. The contact portion **322** is a substantially rectangular plate shape that is longer in the left-right direction in a plan view, and extends to the right from the top end of the support portion **321**. The support portion **321** supports the contact portion **322**. The width of the contact portion **322** in the up-down direction is substantially the same as the width of each of the cams **511** to **514** in the up-down direction.

When the first cutting needle rotation processing that will be described later is performed, a CPU **151** (refer to FIG. **6**) moves the embroidery frame **9** such that the contact portion **322** of the embroidery frame **9** comes into contact with and presses the cam member **51**. When the contact portion **322** comes into contact with and presses the cam member **51**, the cam member **51** rotates by 45 degrees. As a result of the above-mentioned processing, the width direction of the blade portion **89** of the cutting needle **8** also extends in the direction in which the cam member **51** has rotated by 45 degrees. Further, before the cutwork operation is started, the embroidery frame **9** is in a position in which the contact portion **322** is separated to the left from the cam member **51**. Hereinafter, this position is referred to as a withdrawn position.

An electrical configuration of the sewing machine **1** will be explained with reference to FIG. **6**. A control portion **105** of the sewing machine **1** is provided with the CPU **151**, a ROM **152**, a RAM **153**, a flash memory **64** and an input/output interface **66**. The CPU **151**, the ROM **152**, the RAM **153**, the flash memory **64** and the input/output interface **66** are electrically connected to each other via a bus **67**. Various programs, including programs for the CPU **151** to execute cutwork execution processing and the first cutting needle rotation processing to be explained later, are stored in the ROM **152**. Various information that is processed by the programs is temporarily stored in the RAM **153**.

The flash memory **64** includes a cutwork data storage area **641**, a cam number data storage area **642**, a cutting needle angle storage area **643**, a drive shaft stop angle storage area **644** and a rotation difference amount storage area **645** etc. Each of the storage areas will be explained in more detail later.

Cutting needle angles of the cutting needle **8** that are referred to in the cutwork execution processing (to be explained later) are stored in the cutting needle angle storage area **643**. Here, the cutting needle angle is an angle formed in a plan view between the width direction of the blade portion **89** of the cutting needle **8** and a reference direction (the left-right direction). The cutting needle angle is zero degrees when the width direction of the blade portion **89** extends in the left-right direction (a state of the blade portion **89** shown in FIG. **2**), and in a plan view in FIG. **2**, the counterclockwise direction is the positive direction. The cutting needle angle of the cutting needle **8** that is initially attached to the needle bar **6** is zero degrees, and an initial value of the cutting needle angle stored in the cutting needle angle storage area **643** is also "0 degrees."

As shown in FIG. **6**, the operation switches **35**, the touch panel **26**, a detection portion **27** and drive circuits **70** to **76** are electrically connected to the input/output interface **66**. The detection portion **27** detects a type of the embroidery frame that is mounted on the frame holder (not shown in the drawings). Although not shown in the drawings, the sewing machine **1** is provided with a plurality of types of the embroidery frame. The detection portion **27** detects at least which of the embroidery frame **9** and an embroidery frame **10** that will be explained later is mounted on the frame holder, and transmits a detection result to the CPU **151** via the input/output interface **66**. The drive circuits **70** to **76** drive the presser motor **99**, the sewing machine motor **79**, the movement motor **80**, the swinging motor **81**, the X axis motor **82**, the Y axis motor **83** and the liquid crystal display **15**, respectively.

An encoder **77** is a detector that detects a rotation angle of the drive shaft **72**. The encoder **77** detects the rotation angle of the drive shaft **72** and transmits the detected rotation angle to the CPU **151** via the input/output interface **66**.

Cutwork pattern data **100** will be explained with reference to FIG. **7**. The cutwork pattern data **100** is stored in the cutwork data storage area **641** (refer to FIG. **6**). The cutwork pattern data **100** is data that is referred to by the CPU **151** in the cutwork execution processing and the first cutting needle rotation processing that will be explained later. The blade portion **89** of the cutting needle **8** has the width that is orthogonal to the axial line of the cutting needle **8** (the left-right direction in FIG. **4**). Thus, the direction of a cut formed in the work cloth (not shown in the drawings) by the cutting needle **8** is the same as the width direction. As a result, when the work cloth is cut using the cutting needle **8** along a contour of a specific pattern that is formed of a curved line, for example, along with moving the embroidery frame **9** in the X direction and the Y direction, it is necessary to rotate the cutting needle **8** and change the direction of the cuts formed in the work cloth. The cutwork pattern data **100** is data to generate a specific pattern etc. by cutting out the work cloth. The cutwork pattern data **100** is stored in the cutwork data storage area **641** for each cutwork pattern that is formed in the work cloth by the sewing machine **1**.

The cutwork pattern data **100** includes a needle drop number N, X coordinate data, Y coordinate data and cutting needle angle data, and each of the data items are stored in association with each other. The needle drop number N is a variable that indicates an order in which the work cloth is cut. "CUT_END" that is noted in the lowest column of the needle drop number N is a final number of the needle drop number N and is a number such as **200** or **300** etc. In the following explanation, "CUT_END" is a maximum value of the needle drop number N of the cutwork pattern data **100**. The X coordinate data and the Y coordinate data are data of coordinates of needle drop points (points at which a center portion of the blade portion **89** pierces the work cloth) in an embroidery coordinate system that is specific to the sewing machine **1** and that is set in advance. It should be noted that a position at which a center point of the embroidery frame **9** is aligned with a needle drop point is an origin point of the embroidery coordinate system. The cutting needle angle data is data indicating the cutting needle angle of the cutting needle **8**.

The cam number data **210** will be explained with reference to FIG. **8**. The cam number data **210** is stored in the cam number data storage area **642**. The cam number data **210** is data that is referred to by the CPU **151** in the first cutting needle rotation processing that will be explained later. The cam number data **210** includes cutting needle angle difference data and data of a current cutting needle angle. Here, the cutting needle angle difference refers to a value that is obtained by subtracting the cutting needle angle of the cutting needle **8** at a present time (hereinafter referred to as a "current cutting needle angle") from a cutting needle angle of the cutting needle **8** that is desired to be set (hereinafter referred to as a "set cutting needle angle"). The data of the current cutting needle angle further includes a number of contacts P. As described above, in the cam number data **210**, data of the contact cam number is stored in association with each item of the cutting needle angle difference data, the current cutting needle angle and the number of contacts P. The data of the contact cam number is "1" to "4" and corresponds to each of the cams **511** to **514**. The cutting needle angle difference data is "45 degrees," "90 degrees" and "135 degrees." The current cutting needle angle data is "0 degrees," "45 degrees," "90 degrees" and "135 degrees." The cutting needle angle difference data only has three values because the cutting needle **8** only rotates by 45 degrees at a time and when the cutting needle angle is 180 degrees, that is the same as 0 degrees. The number of contacts P is divided into "P=1," "P=2" and "P=3" for each of the current cutting needle angle data. The number of contacts P is 1 to 3 because the cutting needle **8** only rotates by 45 degrees at a time and when the cutting needle **8** performs four rotations, the cutting needle angle becomes 180 degrees, which means that the cutting needle angle is essentially 0 degrees.

Drive shaft stop angle data **220** that is stored in the drive shaft stop angle storage area **644** (refer to FIG. **6**) will be explained with reference to FIG. **9**. The drive shaft stop angle data **220** is data that is referred to by the CPU **151** in the first cutting needle rotation processing that will be explained later. In the drive shaft stop angle data **220**, a cam number M and drive shaft stop angle data are stored in association with each other. The cam numbers M **1** to **4** correspond to the cams **511** to **514**, respectively. The drive shaft stop angle data **220** is data indicating a rotation angle at which the drive shaft **72** stops, and is data that is used to stop the needle bar **6** at a position at which the contact portion **322** is the same height as the contact receiving portion of the cam that corresponds to the cam number M.

Rotation difference amount data **230** that is stored in the rotation difference amount storage area **645** (refer to FIG. **6**) will be explained with reference to FIG. **10**. The rotation difference amount data **230** is data that is referred to by the CPU **151** in the first cutting needle rotation processing that will be explained later. As will be described later, when the CPU **151** causes the contact portion **322** to successively come into contact with the cams **511** to **514**, the CPU **151** refers to the rotation difference amount data **230**. Here, the rotation difference amount data **230** is data of a rotation amount of the drive shaft **72** that is used to move and stop the needle bar **6** such that, after the contact portion **322** has come into contact with one of the cams **511** to **514**, the contact portion **322** is at a height at which it can come into contact with another of the cams **511** to **514**. In the rotation difference amount data **230**, data of the rotation difference amount is set and stored in association with each of the current cam number M and the cam number M with which contact will next be caused (hereinafter referred to as the next contact cam number M). The current cam number M is the number of the cam that was in contact with the contact portion **322** immediately before. The numbers 1 to 4 of the current cam numbers M correspond to the cams **511** to **514**, respectively. When the contact portion **322** comes successively into contact with the cams **511** to **514**, the next contact cam number M is the number of the cam that will next come into contact with the contact portion **322**. The numbers 1 to 4 of the next contact cam numbers M correspond to the cams **511** to **514**, respectively.

The cutwork execution processing that is performed by the CPU **151** will be explained with reference to FIG. **11**. The cutwork execution processing is started when the power source of the sewing machine **1** is turned on and the user inputs a command using the operation switches **35** and the touch panel **26** etc. When the CPU **151** of the sewing machine **1** detects the input of the start command of the cutwork execution processing, the CPU **151** reads the program to perform the cutwork execution processing from the ROM **152** (refer to FIG. **6**) into the RAM **153**. Then, the CPU **151** performs each step of the processing as explained below, in accordance with instructions included in the program. The user uses the operation switches **35** and the touch panel **26** etc. to select the cutwork pattern to be made on the work cloth (not shown in the drawings), and commands the cutwork to be executed.

In the cutwork execution processing, first the CPU **151** acquires the cutwork pattern data **100** (step S**11**). The CPU **15** refers to the cutwork data storage area **641**, and acquires the cutwork pattern data **100** associated with the cutwork pattern selected by the user. The CPU **151** sets the needle drop number N to "1" (step S**13**). The set needle drop number N is stored in the RAM **153**. Next, the CPU **151** performs the first cutting needle rotation processing (step S**15**).

The first cutting needle rotation processing will be explained with reference to FIG. **12**. The first cutting needle rotation processing is processing to match the angle indicated by the cutting needle angle data stored in association with the needle drop number N in the cutwork pattern data **100** (refer to FIG. **7**) acquired at step S**11** with the cutting needle angle of the cutting needle **8**.

In the first cutting needle rotation processing, first the CPU **151** acquires the current cutting needle angle of the cutting needle **8** (step S**30**). The CPU **151** refers to the cutting needle angle storage area **643** (refer to FIG. **6**) and acquires the cutting needle angle stored therein. The CPU **151** determines whether the current cutting needle angle is the same as the cutting needle angle associated with the needle drop number N in the cutwork pattern data **100** (step S**31**) The CPU **151** refers to the cutwork pattern data **100** stored in the cutwork data storage area **641** (refer to FIG. **6**), acquires the cutting needle angle associated with the needle drop number N, and compares the acquired cutting needle angle with the current cutting needle angle acquired at step S**30**. When the current cutting needle angle and the cutting needle angle associated with the needle drop number N are the same (yes at step S**31**), the CPU **151** ends the first cutting needle rotation processing and returns the processing to the cutwork execution processing (refer to FIG. **11**).

When the cutting needle angle data acquired from the cutting needle angle storage area **643** is "0 degrees," for example (step S**30**), and the needle drop number N is "1," the cutting needle angle data stored in the cutwork pattern data **100** is also "0 degrees" (yes at step S**31**). In this case, the first cutting needle rotation processing is ended.

As shown in FIG. **11**, after the first cutting needle rotation processing is ended, the CPU **151** performs the cutwork of one stitch associated with the needle drop number N (step S**17**). After the cutwork is performed, the sewing machine motor **79** drives the needle bar up-and-down movement mechanism **84** (refer to FIG. **6**) until the needle bar **6** (that is, the cutting needle **8**) moves to the top needle position. For example, when the needle drop number N is "1," in the cutwork pattern data **100**, the X coordinate data of the needle drop point is "x1" and the Y coordinate data is "y1" as shown in FIG. 7. The CPU **151** therefore controls the drive circuits **74** and **75**, drives the X axis motor **82** and the Y axis motor **83**, and moves the embroidery frame **9** such that the needle drop point is at the X coordinate "x1" and the Y coordinate "y1." Then the CPU **151** controls the drive circuit **71**, drives the sewing machine motor **79**, and lowers the needle bar **6**. As a result of the above-described processing, the cutwork is performed in which the blade portion **89** of the cutting needle **8** cuts the work cloth. The CPU **151** controls the drive circuit **71** and drives the sewing machine motor **79**, and thus drives the needle bar up-and-down movement mechanism **84** (refer to FIG. **6**) until the cutting needle **8** moves to the top needle position.

Next, the CPU **151** determines whether the needle drop number N is "CUT_END" (step S**19**). The CPU **151** performs the determination by referring to the needle drop number N stored in the RAM **153**, and then comparing this needle drop number N to the needle drop number N "CUT_END" of the cutwork pattern data **100** that is stored in the cutwork data storage area **641** (refer to FIG. **6**).

When it is determined that the needle drop number N is not "CUT_END" (no at step S**19**), the CPU **151** increments the needle drop number N (step S**21**), and the incremented needle drop number N is stored in the RAM **153**. After this, the CPU **151** returns the processing to step S**15**. For example, when the needle drop number N is "1" (no at step S**19**), the needle drop number N is incremented to "2" (step S**21**).

When the needle drop number N is "CUT_END" (yes at step S**19**), the CPU **151** overwrites and stores the current cutting needle angle in the cutting needle angle storage area **643** (step S**23**).

For example, when the needle drop number N is "CUT_END" (yes at step S**19**), the cutting needle angle data in the cutwork pattern data **100** is "0 degrees" (refer to FIG. **7**) and the current cutting needle angle is 0 degrees. The CPU **151** sets the current cutting needle angle as "0 degrees," overwrites the cutting needle angle stored in the cutting needle angle storage area **643**, and stores the current cutting needle angle (step S**23**).

Next, the CPU **151** controls the drive circuits **74** and **75**, drives the X axis motor **82** and the Y axis motor **83**, thus moving the embroidery frame **9** to the withdrawn position (step S**25**). After the embroidery frame **9** has been moved to the withdrawn position, the CPU **151** ends the cutwork execution processing. Note that, when the cutwork execution processing is ended, the cutting needle **8** is in the top needle position.

In the first cutting needle rotation processing shown in FIG. **12**, in a case in which the current cutting needle angle is different to the cutting needle angle associated with the needle drop number N in the cutwork pattern data **100** (refer to FIG. **7**), an explanation will be made when the needle drop number N is "2." When it is determined that the current cutting needle angle and the cutting needle angle associated with the needle drop number N are different (no at step S**31**), the CPU **151** acquires a cutting needle angle difference (step S**32**). The CPU **151** refers to the cutwork pattern data **100** stored in the cutwork data storage area **641** (refer to FIG. **6**), and thus acquires the cutting needle angle associated with the needle drop number N. The CPU **151** subtracts the value of the current cutting needle angle acquired at step S**30** from the acquired cutting needle angle associated with the needle drop number N, and thus acquires the cutting needle angle difference.

For example, when the needle drop number N is "2," at step S**17** of the cutwork execution processing (refer to FIG. **11**), the CPU **151** has completed the cutwork for one stitch when the needle drop number N is "1." As shown in FIG. **7**, when the needle drop number N is "1," the corresponding cutting needle angle data is "0 degrees." Specifically, the current cutting needle angle of the cutting needle **8** is 0 degrees. When the needle drop number N is "2," the corresponding cutting needle angle data is "45 degrees," and is different to the current cutting needle angle (no at step S**31**). The set cutting needle angle is 45 degrees. Thus, the CPU **151** subtracts the current cutting needle angle (0 degrees) from the set cutting needle angle (45 degrees) and thereby acquires 45 degrees as the cutting needle angle difference (step S**32**).

As shown in FIG. **12**, the CPU **151** next sets "1" as the number of contacts P (step S**33**) and stores the set number of contacts P in the RAM **153**. After that, the CPU **151** acquires the next contact cam number M (step S**34**). For example, when the needle drop number N is "2," as described above, the current cutting needle angle is "0 degrees" and the cutting needle angle difference acquired at step S**32** is "45 degrees." Further, the number of contacts P is "1" (step S**33**). In this case, as shown in FIG. **8**, in the cam number data **210**, the cam number "2" is stored in association with the cutting needle angle difference "45 degrees," the current cutting needle angle "0 degrees" and the number of contacts P "1." Thus, the CPU **151** acquires "2" as the next contact cam number M (step S**34**).

Next, the CPU **151** controls the drive circuits **74** and **75**, drives the X axis motor **82** and the Y axis motor **83**, and lowers the embroidery frame **9** to the withdrawn position (step S**35**). For example, when the needle drop number N is "2," at step S**17** of the cutwork execution processing (refer to FIG. **11**), the CPU **151** has completed the cutwork for one stitch when the needle drop number N is "1." As shown in FIG. **7**, when the needle drop number N is "1," the X coordinate data of the corresponding needle drop point is "x1," and the Y coordinate data is "y1." In other words, the embroidery frame **9** is not in the withdrawn position and therefore the CPU **151** controls the drive circuits **74** and **75** and moves the embroidery frame **9** to the withdrawn position (step S**35**).

Next, the CPU **151** determines whether the needle bar **6** (that is, the cutting needle **8**) is in the top needle position (step S**38**). The CPU **151** determines whether the cutting needle **8** is in the top needle position, based on a signal output from the encoder **77** (refer to FIG. **6**). When it is determined that the cutting needle **8** is in the top needle position (yes at step S**38**), the CPU **151** refers to the drive shaft stop angle data **220** that is stored in the drive shaft stop angle storage area **644** (refer to FIG. **6**), and thus acquires the drive shaft stop angle data associated with the cam number M acquired at step S**34** (step S**39**).

For example, when the needle drop number N is "2" and the number of contacts P is 1, by the processing by the CPU **151** at step S**17** of the cutwork execution processing (refer to FIG. **11**), the cutting needle **8** is in the top needle position (yes at step S**38**). As described above, when the needle drop number N is "2," the next contact cam number M acquired at step S**34** is "2." In this case, as shown in FIG. **9**, a drive shaft stop angle "A2" that is stored in the drive shaft stop angle data **220** is acquired (step S**39**). The contact receiving portion of the cam associated with the next contact cam number M "2" is the contact receiving portion **612** (refer to FIG. **5**). Specifically, the drive shaft stop angle "A2" is set to move and stop the needle bar **6** such that the contact receiving portion **612** is at a height at which it can come into contact with the contact portion **322** (refer to FIG. **3**).

Next, the CPU **151** controls the drive circuit **71**, drives the sewing machine motor **79** such that the rotation angle of the drive shaft **72** is the drive shaft stop angle "A2" acquired at step S**39**, and moves the needle bar **6** (step S**43**).

Next, the CPU **151** controls the drive circuit **74**, drives the X axis motor **82**, and moves the embroidery frame **9** toward the right (the direction of an arrow A shown in FIG. **13**) (step S**49**). By this movement, the contact portion **322** comes into contact with and presses the contact receiving portion **612** of the cam **512** that corresponds to the cam number M "2" acquired at step S**34**. More specifically, the contact portion **322** presses a portion of the contact receiving portion **612** that is to the front and the right of the cutting needle **8** to the right. By this pressing, the contact portion **322** causes the cam **512** to rotate in the counter-clockwise direction (the direction of an arrow B) in a plan view, around the axial line of the cam member **51**. The cam member **51**, the cutting needle **8**, the rotation member **43** and the plate spring **44** also rotate integrally with the rotation of the cam **512**. When the plate spring **44** rotates, the engagement portion **442** resists the urging force imparted by the plate spring **44**, is displaced from the engagement receiving portion **414** with which it was engaged, and moves along the groove portion **415** while rotating in the counter-clockwise direction in a plan view (in the direction of the arrow B). The engagement portion **442** engages with the engagement receiving portion **414** that is adjacent to the engagement receiving portion **414** with which it was hitherto engaged (hereinafter referred to as the next engagement receiving portion **414**). By the above-described processing, the plate spring **44** once more imparts an urging force in the direction in which the engagement portion **442** engages with the next engagement receiving portion **414** (in the direction toward the axial line of the support member **41**). By this urging, the rotation of the cam member **51**, the cutting needle **8** and the rotation member **43** is locked. After the rotation of the rotation member **43**, the angles in the longitudinal direction of the cams **511** to **514** are 135 degrees, 0 degrees, 45 degrees and 90 degrees, respectively.

As shown in FIG. **12**, the CPU **151** next increments the number of contacts P (step S**54**), and stores the incremented value P in the RAM **153**. After that, the CPU **151** determines whether the processing is complete (step S**55**). The CPU **151** refers to the cam number data **210** (refer to FIG. **8**) stored in the cam number data storage area **642** (refer to FIG. **6**), and determines that the processing is complete when the cam number M associated with the current cutting needle angle acquired at step S**30**, the cutting needle angle difference acquired at step S**32** and the number of contacts P incremented at step S**54** is "_". The CPU **151** further determines that the processing is complete when the number of contacts P is "4." When it is determined that the processing is complete (yes at step S**55**), the CPU **151** ends the first cutting needle rotation processing and returns the processing to the cutwork execution processing (refer to FIG. **11**).

When the needle drop number N is "2," for example, as described above, the current cutting needle angle acquired at step S**30** is "0 degrees" and the cutting needle angle difference acquired at step S**32** is "45 degrees." When the number of contacts P is incremented from "1" to "2" (step S**54**), in the cam number data **210**, the cam number associated with the cutting needle angle difference "45 degrees," the current cutting needle angle "0 degrees" and the number of contacts P "2" is "-," as shown in FIG. **8**. It is therefore determined that the processing is complete (yes at step S**55**) and the CPU **151** ends the first cutting needle rotation processing.

Next, a case will be explained in which the execution of the first cutting needle rotation processing is started and it is determined at step S**55** that the processing is not complete. In the following explanation, it is assumed that the needle drop number N is "3." When the needle drop number N is "3," the outwork of one stitch has been performed when the needle drop number N is "2" at step S**17** in the cutwork execution processing (refer to FIG. **11**). In the cutwork pattern data **100** (refer to FIG. **7**), when the needle drop number N is "2," the cutting needle angle data is "45 degrees," and when the needle drop number N is. "3," the cutting needle angle data is "135 degrees." Therefore, the current cutting needle angle acquired at step S**30** is "45 degrees." Further, the cutting needle angle difference acquired at step S**32** is "90 degrees," which is obtained by subtracting 45 degrees from 135 degrees. In addition, in the cam number data **210** shown in FIG. **8**, the cam number data associated with the current cutting needle angle "45 degrees," the cutting needle angle difference "90 degrees" and the number of contacts P "1" is "1." As a result, the contact cam number M acquired at step S**34** is "1."

When the needle drop number N is "3," at step S**17** of the cutwork execution processing (refer to FIG. **11**), the cutwork of the one stitch associated with the needle drop number N of "2" has already been performed, and the needle drop number N is incremented at step S**21**. After that, the execution of the first cutting needle rotation processing is started once more. In this case, the processing from step S**30** to step S**54** is the same as in the above explanation.

As shown in FIG. **12**, the CPU **151** determines whether the processing is complete (step S**55**). When the needle drop number N is "3," for example, as described above, the current cutting needle angle acquired at step S**30** is "45 degrees," and the cutting needle angle difference acquired at step S**32** is "90 degrees." As shown in FIG. **8**, in the cam number data **210**, the cam number associated with the current cutting needle angle "45 degrees," the cutting needle angle difference "90 degrees" and the number of contacts P "2" that is incremented at step S**54** is "4" and is not "-." Further, the incremented number of contacts P is "2" and is not "4." As a result, it is determined that the processing is not complete (no at step S**55**).

Next, the CPU **151** acquires the current cam number M (step S**57**). The CPU **151** acquires the next contact cam number M (acquired at step S**34**) as the current cam number. As described above, the cam number already acquired at step S**34** is "1," for example. Therefore, the current cam number M is acquired as "1."

The CPU **151** acquires the next contact cam number of the current cam number (step S**34**). For example, in the cam number data **210** shown in FIG. **8**, the cam number associated with the current cutting needle angle "45 degrees," the cutting needle angle difference "90 degrees" and the number of contacts P "2" is "4." Thus, "4" is acquired as the next contact cam number M (step S**34**).

Next, the CPU **151** performs step S**35**. This processing is the same as in the explanation above and an explanation is therefore omitted here.

Next, the CPU **151** determines whether the cutting needle **8** is in the top needle position (step S**38**). When it is determined that the cutting needle **8** is not in the top needle position (no at step S**38**), the CPU **151** advances the processing to step S**40**. For example, when the needle drop number N is "3" and the number of contacts P is "2," the CPU **151** has already performed the processing associated with the number of contacts P "1." In other words, the contact portion **322** is positioned at the height in which it can come into contact with the contact receiving portion **611**, and the cutting needle **8** is not in the top needle position (no at step S**38**).

Next, the CPU **151** acquires the rotation difference amount (step S**40**). The CPU **151** refers to the current cam number M acquired at step S**57**, the next contact cam number M acquired at step S**34** and the rotation difference amount data **230** stored in the rotation difference amount storage area **645** (refer to FIG. **6**), and acquires the rotation difference amount.

When the needle drop number N is "3," and the number of contacts P is "2," for example, as described above, the current cam number M acquired at step S**57** is "1" and the next contact cam number M acquired at step S**34** is "4." As shown in FIG. **10**, in the rotation difference amount data **230**, the rotation difference amount associated with the current cam number M "1" and the next contact cam number M "4" is "A14." Therefore, the rotation difference amount "A14" is acquired (step S**40**). The contact receiving portion of the cam that corresponds to the next contact cam number M "4" is the contact receiving portion **614** (refer to FIG. **5**). In other words, the rotation difference amount "A14" is set that moves and stops the needle bar **6** such that the contact receiving portion **614** is at a height at which it can come into contact with the contact portion **322** (refer to FIG. **3**).

Next, the CPU **151** controls the drive circuit **71**, drives the sewing machine motor **79** such that the drive shaft **72** is rotated by the rotation difference amount "A14" acquired at step S**40**, and moves the needle bar **6** (step S**43**).

Next, the CPU **151** performs the processing at step S**49**. This processing is the same as that in the above explanation.

After incrementing the number of contacts P (step S**54**), the CPU **151** determines whether the processing is complete (step S**55**). For example, when the needle drop number N is "3" and the number of contacts P is "2," the number of contacts P is incremented to "3" (step S**54**). As described above, the current cutting needle angle acquired at step S**30** is "45 degrees" and the cutting needle angle difference acquired at step S**32** is "90 degrees." As shown in FIG. **8**, in the cam number data **210**, the cam number associated with the current cutting needle angle "45 degrees," the cutting needle angle difference "90 degrees" and the number of contacts P "3" is "-" It is therefore determined that the processing is complete (yes at step S**55**) and the first cutting needle rotation processing is ended.

As explained above, the CPU **151** of the sewing machine **1** drives the sewing machine motor **79** and moves the cutting needle **8** to a position at which the contact portion **322** is the same height as one of the contact receiving portions **611** to **614** (step S**43**). Then, the CPU **151** drives the X axis motor **82**, moves the embroidery frame **9** that is in the withdrawn position to the right, causes the contact portion **322** to come into contact with and rotate one of the contact receiving portions **611** to **614** (step S**49**). By this rotation, the CPU **151** rotates the cutting needle **8** by 45 degrees in the counter-clockwise direction. Thus, the sewing machine **1** can automatically cause the cutting needle **8** to rotate. Further, as the contact receiving portions **611** to **614** have the width in the up-down direction, when the embroidery frame **9** moves to the right, the contact portion **322** reliably comes into contact with the contact receiving portion of the cam associated with the next contact cam number M acquired at step S**34**. As a result, the sewing machine **1** can cause the cutting needle **8** to rotate in a stable manner.

In the rotation direction centered on the axial line of the cam member **51**, the longitudinal direction of each of the contact receiving portions **611** to **614** is displaced by 45 degrees, in a plan view, with respect to the mutually adjacent contact receiving portion. With the above-described structure, among the contact receiving portions **611** to **614**, the contact portion **322** comes into contact with the contact receiving portion of the cam whose longitudinal direction angle is 135 degrees and the cutting needle **8** is rotated by 45 degrees. After that, the longitudinal direction angle of one of the cams with which contact was not made becomes 135 degrees. In other words, when the cutting needle **8** rotates by 45 degrees at a time, the longitudinal direction angle of one of the cams **511** to **514** becomes 135 degrees. When causing the contact portion **322** to come into contact with one of the cams **511** to **514**, the sewing machine **1** can always position the embroidery frame **9** at the same coordinate position. Namely, the sewing machine **1** can simplify the movement control of the embroidery frame **9**. As a result, the sewing machine **1** can cause the cutting needle **8** to rotate in a more stable manner.

In addition, the engagement portion **442** of the plate spring **44** engages with one of the plurality of engagement receiving portions **414**. As a result, the plate spring **44** urges the support member **41** in the direction in which the engagement portion **442** engages with the engagement receiving portion **414**. By this urging, the rotation of the rotation member **43** is locked and the rotation of the cutting needle **8** is also locked. The sewing machine **1** can suppress unnecessary rotation of the cutting needle **8** when performing the outwork on the work cloth. The sewing machine **1** can therefore perform the cutwork on the work cloth in a stable manner. Furthermore, the cutting needle angle of the cutting needle **8** is determined by the position at which the engagement portion **442** engages with the next engagement receiving portion **414**. As a result, the sewing machine **1** can accurately control the cutting needle angle of the cutting needle **8**.

Note that the present disclosure is not limited to the above-described embodiment, and various modifications are possible. For example, in the above-described embodiment, the four cams **511** to **514** of the cam member **51** are arranged such that their respective angles in the longitudinal direction are mutually displaced by 45 degrees in a plan view. In place of the above-described arrangement, six cams may be provided, and their respective angles in the longitudinal direction may be mutually displaced by 30 degrees. Further, each of the shape, the size, the number and the angle in the longitudinal direction of the cam may be changed as appropriate.

Further, in the above-described embodiment, the contact portion **322** is provided such that it extends to the right from the support portion **321**. However, the shape, size and installation position of the contact portion may be changed as appropriate. For example, the contact portion **322** may extend to the front or to the rear, and the embroidery frame **9** may be moved to the front or to the rear and caused to come into contact with the cam member **51**. Further, the contact portion **322** is provided on the outer frame **91**, but it may be provided on the inner frame.

Further, in the above-described embodiment, only the one protruding portion **320** is provided on the outer frame **91** of the embroidery frame **9**. Instead of the above-described structure, four protruding portions that correspond to each of the cams **511** to **514** may be provided. For example, as shown in FIG. **14**, four protruding portions **111** to **114** are provided, from the front to the rear of the outer frame **91**.

The protruding portion **111** is provided with a support portion **121** and a contact portion **131**, the protruding portion **112** is provided with a support portion **122** and a contact portion **132**, the protruding portion **113** is provided with a support portion **123** and a contact portion **133**, and the protruding portion **114** is provided with a support portion **124** and a contact portion **134**. The support portions **121** to **124** each protrude upward from the outer frame **91**. The height of each of the support portions **121** to **124** becomes increasingly higher in order, from the support portion **121** to the support portion **124**. Each of the contact portions **131** to **134** is a plate that extends to the right from the top end of each of the support portions **121** to **124**. The contact portions **131** to **134** all have the same shape and their width in the up-down direction is the same as the width of the cams **511** to **514** in the up-down direction. In a state in which the needle bar **6** is stopped such that the top surface of the cam **511** is at a same position as the top surface of the contact portion **134**, the top surfaces of the cams **512** to **514** are at the same heights as the contact portions **132** to **134**, respectively.

Specifically, when the cutting needle **8** is lowered by a predetermined amount from the top needle position, the contact portion **131** is at a height at which it can come into contact with the contact receiving portion **614**, the contact portion **132** is at a height at which it can come into contact with the contact receiving portion **613**, the contact portion **133** is at a height at which it can come into contact with the contact receiving portion **612**, and the contact portion **134** is at a height at which it can come into contact with the contact receiving portion **611**. In addition, a coordinate position of the embroidery frame **9** at which each of the contact portions **131** to **134** can press the contact receiving portions **611** to **614** may be stored in a specific storage area of the flash memory **64**. In this case, when the CPU **151** rotates the cutting needle **8** a plurality of times, such as when the CPU **151** rotates the cutting needle **8** by 45 degrees three times, for example, it is not necessary to re-set the height of the needle bar **6** after the first rotation has ended. In other words, after the first contact has ended at step **S49** in the first cutting needle rotation processing, at step **S35**, the CPU **151** moves the embroidery frame **9** while referring to the specific storage area in the flash memory **64** in order to selectively cause one of the contact portions **131** to **134** to come into contact with the cam member **51**. With the above-described structure, from the second contact onward, it is possible to render the processing at step S40 and step S43 unnecessary in the first cutting needle rotation processing.

Next, a sewing machine **2** according to a second embodiment of the present disclosure will be explained with reference to FIG. **15** to FIG. **21**. In FIG. **15**, members that are the same as those of the sewing machine **1** are assigned the same reference numerals. In the following explanation, an explanation will be omitted of configurations and operations that are the same as those of the sewing machine **1** according to the first embodiment. Note that, in the present embodiment, the cutting needle angle is 0 degrees in a state in which the blade portion **89** extends in the left-right direction (a state of the blade portion **89** shown in FIG. **16**), and, in contrast to the first embodiment, the counter-clockwise direction in a plan view in FIG. **15** is the positive direction.

As shown in FIG. **15** and FIG. **16**, the sewing machine **2** is different to the sewing machine **1** in that the sewing machine **2** is provided with a cutting needle rotation mechanism **60** instead of the cutting needle rotation mechanism **50** (refer to FIG. **4**) that is provided on the sewing machine **1**. The other physical structure and the electrical configuration of the sewing machine **2** are basically the same as those of the sewing machine **1**. The cutting needle rotation mechanism **60** is provided with a support mechanism **61**, a holding member **62** and the cutting needle **8**. The shape of the cutting needle **8** of the cutting needle rotation mechanism **60** is the same as the shape of the cutting needle **8** of the cutting needle rotation mechanism **50**.

The support mechanism **61** is provided with the support member **41**, a rotation member **63** and the plate spring **44**. The shape of the support member **41** and the plate spring **44** of the support mechanism **61** is the same as the shape of the support member **41** and the plate spring **44** of the support mechanism **40** and an explanation thereof is therefore omitted here.

The rotation member **63** is substantially cylindrical and is rotatably supported by the lower end of the support member **41**. The axial line of the rotation member **63** is aligned with the axial line of the needle bar **6** (refer to FIG. **3**). The rotation member **63** is provided with a protruding portion **621** that extends in a direction orthogonal to the axial line of the rotation member **63** (in the left-right direction in FIG. **16**). The protruding portion **621** is a shaft member that is pressed into a through hole (not shown in the drawings) provided in the rotation member **63**. The direction in which the protruding portion **621** extends is the same as the width direction of the blade portion **89** of the cutting needle **8**. The protruding portion **621** is provided with a first protruding portion **631** and a second protruding portion **632**. The first protruding portion **631** and the second protruding portion **632** protrude toward a direction that moves away from the axial line of the rotation member **63**. The first protruding portion **631** and the second protruding portion **632** are provided such that they are symmetrical, centering on the axial line of the rotation member **63**. Apart from the provision of the protruding portion **621**, the rotation member **63** of the support mechanism **61** is the same as the rotation member **43** of the support mechanism **40**.

The holding member **62** is a substantially cylindrical member that extends downward from a central portion of the lower end surface of the rotation member **63**. The holding member **62** is integrally formed with the rotation member **63**. The axial line of the holding member **62** is aligned with the rotation member **63**. In a similar manner to the can member **51** of the cutting needle rotation mechanism **50**, a shaft hole (not shown in the drawings) is provided in the lower end of the holding member **62**. The upper end of the cutting needle **8** is inserted into the shaft hole and is fixed by the screw **20**.

An embroidery frame **10** will be explained with reference to FIG. **15**, FIG. **17** and FIG. **18**. The sewing machine **2** is provided with the embroidery frame **10** in place of the embroidery frame **9** (refer to FIG. **1**) with which the sewing machine **1** is provided. The embroidery frame **10** is the same as the embroidery frame **9**, apart from a support member **700** that is provided on the embroidery frame **10** in place of the protruding portion **320** provided on the embroidery frame **9**.

The support member **700** is a substantially rectangular shape that is longer in the front-rear direction in a plan view. The support member **700** is provided on a right side portion of an outer frame **11** of the embroidery frame **10**. The support portion **700** is formed integrally with the outer frame **11**. Four guide portions **711** to **714** are provided in a row on the support portion **700**, from the front to the rear. As will be described below, each of the guide portions **711** to **714** guides the protruding portion **621** of the cutting needle rotation mechanism **60**, and the cutting needle **8** can thus be rotated and the cutting needle angle can be changed.

The angle (the orientation) in a plan view of each of the four guide portions **711** to **714** is different, but apart from the angle, each of the guide portions **711** to **714** has the same shape. Thus, for ease of explanation, the structure of the guide portion **712** will be explained. Points of difference between the four guide portions **711** to **714** will be explained later. As shown in FIG. **17** and FIG. **18**, the guide portion **712** includes a first insertion hole **802**, a first inclined portion **812**, a second inclined portion **822**, a second insertion hole **872** and groove portions **832**. The first insertion hole **802** is a circular hole, in a plan view, that penetrates through the support portion **700** in the up-down direction. The inner diameter of the first insertion hole **802** is larger than the length between both ends of the protruding portion **621**.

The first inclined portion **812** and the second inclined portion **822** are provided along the inner peripheral surface of the first insertion hole **802**. The first inclined portion **812** and the second inclined portion **822** form a shape that has point symmetry with respect to the axial line of the first insertion hole **802**. A first guide surface **852** that is the top surface of the first inclined portion **812**, and a second guide surface **862** that is the top surface of the second inclined portion **822** are inclined downward along the inner peripheral surface of the first insertion hole **802**, in the clockwise direction in a plan view.

The second insertion hole **872** is formed on the inside of the first inclined portion **812** and the second inclined portion **822**. The second insertion hole **872** is a circular hole in a plan view that penetrates through the support portion **700** in the up-down direction. The axial line of the second insertion hole **872** is aligned with an axial line of the first insertion hole **802**.

The groove portions **832** are portions at which one end of the first inclined portion **812** (the end in the counter-clockwise direction in a plan view) and one end of the second inclined portion **822** (the end in the clockwise direction in a plan view) face each other and at which the other end of the first inclined portion **812** and the other end of the second inclined portion **822** face each other. The two groove portions **832** are provided on either side of the axial line of the first insertion hole **802**. The groove portions **832** are connected to the lower end of the first guide surface **852** and the lower end of the second guide surface **862**, respectively. The width of each of the groove portions **832** is slightly larger than the outer diameter of the protruding portion **621**.

The groove portions **832** extend toward the front right side from the rear left side in a plan view. Taking the left-right direction as a reference, when the counter-clockwise direction is taken as the positive direction in a plan view, the angle of the direction in which the groove portions **832** extend in a plan view (hereinafter referred to as an "extending direction angle") is 45 degrees. As will be explained later, the protruding portion **621** that moves while being guided by the first guide surface **852** and the second guide surface **862** fits into the groove portions **832**. Specifically, the protruding portion **621** is guided by the first guide surface **852** and the second guide surface **862** and rotates around the axial line of the second insertion hole **872**, and the cutting needle angle becomes the same as the extending direction angle of the groove portions **832**. At that time, the head portion of the screw **20** that is screwed into the holding member **62** also rotates, but the size of the second insertion hole **872** is set such that interference with the head portion of the screw **20** does not occur.

As described above, the shape of the guide portions **711**, **713** and **714** shown in FIG. **17** is the same as that of the guide portion **712**, and each of the guide portions **711**, **713** and **714** is provided with a first insertion hole and a second insertion hole. Meanwhile, the angles at which respective first inclined portions, second inclined portions and groove portions of the guide portions **711**, **713** and **714** are provided are different in a plan view. The extending direction angle of groove portions **831** of the guide portion **711** is 0 degrees. The extending direction angle of groove portions **833** of the guide portion **713** is 90 degrees. The extending direction angle of groove portions **834** of the guide portion **714** is 135 degrees. The angle at which each of the inclined surfaces is provided is also different, in accordance with the angle of the groove portions. Note that, in FIG. **17**, the reference numerals of the structural members of the guide portions **711**, **713** and **714** are assigned in accordance with the reference numerals of the structural members of the guide portion **712**.

Next, guide portion number data **300** will be explained with reference to FIG. **19**. The guide portion number data **300** is stored in a guide portion number data storage area (not shown in the drawings) of the flash memory **64**. The guide portion number data **300** is data that is referred to by the CPU **151** in second cutting needle rotation processing that will be explained later. The guide portion number data **300** includes the cutting needle angle data, a guide portion number K, X coordinate data and Y coordinate data, and each of the data items are stored in association with each other. The guide portion number K is data indicating the guide portions **711** to **714**. The guide portion number K "1" corresponds to the guide portion **711**, the guide portion number K "2" corresponds to the guide portion **712**, the guide portion number K "3" corresponds to the guide portion **713**, and the guide portion number K "4" corresponds to the guide portion **714**. A value that is equal to the extending direction angle of the groove portions of the guide portion associated with the guide portion number K is stored in the cutting needle angle data. Among the guide portion **711** to **714**, the X coordinate data and the Y coordinate data indicate a coordinate position of the embroidery frame **10** at which a central position of the first insertion hole of the guide portion associated with the guide portion number K is the needle drop point.

Cutwork execution processing that is performed by the CPU **151** of the sewing machine **2** will be explained with reference to FIG. **11** and FIG. **20**. The cutwork execution processing performed by the sewing machine **2** is the same as that performed by the sewing machine **1** except that the first cutting needle rotation processing performed by the CPU **151** of the sewing machine **1** at step S**15** is replaced by the second cutting needle rotation processing performed by the CPU **151** of the sewing machine **2** at step S**15**. In the following explanation, the second cutting needle rotation processing will be explained for a case in which the needle drop number N is "2." The second cutting needle rotation processing is processing to match the cutting needle angle data stored in association with the needle drop number N in the cutwork pattern data **100** (refer to FIG. **7**) with the cutting needle angle of the cutting needle **8**.

As shown in FIG. **20**, in the second cutting needle rotation processing, first the CPU **151** acquires the current cutting needle angle of the cutting needle **8** (step S**60**). The CPU **151** refers to the cutting needle angle storage area **643** (refer to FIG. **6**) of the flash memory **64** and acquires the stored cutting needle angle. The CPU **151** determines whether the current cutting needle angle is the same as the cutting needle angle associated with the needle drop number N in the cutwork pattern data **100** (refer to FIG. **7**) (step S**61**). The CPU **151** refers to the cutwork pattern data **100** stored in the cutwork data storage area **641** (refer to FIG. **6**) of the flash memory **64** and acquires the cutting needle angle associated with the needle drop number N, then compares it with the current cutting needle angle acquired at step S**30**. When the current cutting needle angle and the cutting needle angle associated with the needle drop number N are the same (yes at step S**61**), the CPU **151** ends the second cutting needle rotation processing and returns the processing to the cutwork execution processing (refer to FIG. **11**).

For example, when the cutting needle angle data acquired from the flash memory **64** is "0 degrees" (step S**60**) and the needle drop number N is "1," the cutting needle angle data stored in the cutwork pattern data **100** is also "0 degrees" (yes at step S**61**). In this case, the second cutting needle rotation processing is ended.

When the current cutting needle angle and the cutting needle angle associated with the needle drop number N are different (no at step S**61**), after acquiring the guide portion number K (step S**63**), the CPU **151** sets the movement position of the embroidery frame **10** (step S**65**). The CPU **151** refers to the guide portion number data **300** stored in the guide portion number data storage area (not shown in the drawings) of the flash memory **64**, and acquires the guide portion number K that is associated with the cutting needle angle data that is the same as the cutting needle angle acquired at step S**60**. Then, the CPU **151** refers to the guide portion number data **300** and acquires the coordinate data of the embroidery frame **10** associated with the acquired guide portion number K, then sets the movement position of the embroidery frame **10** (step S**65**). The set movement position is stored in the RAM **153**. Next, the CPU **151** controls the drive circuits **74** and **75** and drives the X axis motor **82** and the Y axis motor **83**, thus moving the embroidery frame **10** toward the coordinate position set at step S**65** (step S**67**).

When the needle drop number N is "2," for example, the cutting needle angle data associated with the needle drop number N "2" in the cutwork pattern data **100** is "45 degrees," which is different to the current cutting needle angle (no at step S**61**). Thus, the CPU **151** acquires, from the guide portion number data **300**, the guide portion number K "2" that is associated with the cutting needle angle data "45 degrees" (step S**63**). When the guide portion number K is "2," the X coordinate data of the embroidery frame **10** is "u2" and the Y coordinate data is "v2." For the movement position of the embroidery frame **10**, the CPU **151** sets the X coordinate data to "u2" and the Y coordinate data to "v2" (step S**65**). Then, the CPU **151** moves the embroidery frame **10** to the set position (step S**67**). Through the above-described processing, the movement position of the embroidery frame **10** is determined and the embroidery frame **10** is moved such that the protruding portion **621** can fit with the guide portion **712**, which is associated with the guide portion number K "2."

Next, the CPU **151** controls the drive circuit **71** and drives the sewing machine motor **79**, thus lowering the needle bar **6** (namely, the cutting needle **8**) from the top needle position to a bottom needle position (step S**73**). More specifically, the CPU **151** rotates the drive shaft **72** by 180 degrees, based on a signal output from the encoder **77**. Here, the bottom needle position refers to a lowest position in the movement range of the needle bar **6** in the up-down direction.

When the cutting needle **8** is moved from the top needle position to the bottom needle position, as shown in FIG. **21**, when the cutting needle rotation mechanism **60** is lowered in the direction of an arrow C toward the guide portion **712**, the first protruding portion **631** comes into contact with the first guide surface **852** and the second protruding portion **632** comes into contact with the second guide surface **862**. When the cutting needle rotation mechanism **60** is then lowered further, the first protruding portion **631** is guided along the first guide surface **852** and the second protruding portion **632** is guided along the second guide surface **862** in the clockwise direction (the direction of an arrow D) in a plan view. Thus, the protruding portion **621** rotates in the clockwise direction in a plan view and finally fits into the groove portions **832**.

In accordance with the rotation of the protruding portion **621**, the rotation member **63**, the holding member **62** and the plate spring **44** also rotate integrally in the clockwise direction in the plan view. When the plate spring **44** rotates, the engagement portion **442** resists the urging force imparted by the plate spring **44**, is displaced from the engagement receiving portion **414** with which it was engaged, and moves along the groove portion **415** while rotating in the clockwise direction in a plan view. The engagement portion **442** moves along the groove portion **415** while rotating in the clockwise direction (the direction of the arrow D) in the plan view. The engagement portion **442** engages with the engagement receiving portion **414** that is adjacent to the engagement receiving portion **414** with which it was hitherto engaged (hereinafter referred to as the adjacent engagement receiving portion **414**). Due to the above-described structure, the plate spring **44** once more urges the support member **41**, in the direction in which the engagement portion **442** engages with the adjacent engagement receiving portion **414** (the direction toward the axial line of the support member **41**). By this urging, the rotation of the rotation member **63** is locked. Through the above-described processing, the cutting needle angle of the cutting needle **8** becomes 45 degrees, which is the same as the extending direction angle of the groove portions **832**.

Next, the CPU **151** controls the drive circuit **71** and drives the sewing machine motor **79**, thus raising the needle bar **6** (namely, the cutting needle **8**) from the bottom needle position to the top needle position (step S**79**). More specifically, the CPU **151** rotates the drive shaft **72** by 180 degrees, based on a signal output from the encoder **77**.

In the above explanation, the case is explained in which the needle drop number N is "2," but the processing is performed in the same manner when the needle drop number N is "3," "4," or "CUT_END" etc. As shown in FIG. **7**, the cutting needle angle data that is associated with the needle drop number N "3," "4," and "CUT_END" in the cutwork pattern data **100** is, respectively, "135 degrees," "90 degrees" and "0 degrees." In this case, as shown in the guide portion number data **300** shown in FIG. **19**, the guide portion numbers K associated with the cutting needle angles "135 degrees," "90 degrees" and "0 degrees" are, respectively, "4," "3" and "1." Thus, when the needle drop number N is "4," "3" and "CUT_END," the cutting needle **8** and the rotation member **63** are guided, respectively, by the guide portions **714**, **713** and **711** and the cutting needle angle is thus adjusted.

As explained above, after the embroidery frame **10** is moved to the position determined at step S**65**, the cutting needle **8** is lowered and thus the protruding portion **621** is guided by the first guide surface and the second guide surface of one of the guide portions **711** to **714**. The protruding portion **621** is rotated while being lowered to the position at which it fits with the groove portions **831** to **834** of the guide portions **711** to **714**. As a result; the sewing machine **2** can automatically rotate the cutting needle **8**. Further, the protruding portion **621** is guided by one of the first guide surfaces **851** to **854** and one of the second guide surfaces **861** to **864** of the guide portions **711** to **714**, and thus the protruding portion **621** rotates in a stable manner. The sewing machine **2** can therefore rotate the cutting needle **8** in a stable manner.

Furthermore, the first guide surfaces **851** to **854** and the second guide surfaces **861** to **864** of each of the guide portions **711** to **714** are inclined downward along the circumferential direction of the insertion hole provided in each of the guide portions **711** to **714**. Further, the respective groove portions **831** to **834** of the guide portions **711** to **714** are connected to the lower ends of the first guide surfaces **851** to **854** and the second guide surfaces **861** to **864** of the guide portions **711** to **714**. Therefore, the protruding portion **621** that is guided by the first guide surfaces **851** to **854** and the second guide surfaces **861** to **864** of the guide portions **711** to **714** easily rotates while being lowered, and the rotation stops at the position at which the protruding portion **621** fits with the groove portions. The cutting needle angle of the cutting needle **8** becomes the same as the extending direction angle of the groove portions **831** to **834** of each of the guide portions **711** to **714**. Thus, the sewing machine **2** can rotate the cutting needle **8** in a more stable manner and can also improve the accuracy of the set cutting needle angle of the cutting needle **8**.

The first guide surfaces **851** to **854**, the second guide surfaces **861** to **864** and the two groove portions of each of the guide portions **711** to **714** are provided such that they are symmetrical with respect to the axial line of the first insertion hole of each of the guide portions **711** to **714**. The protruding portion **621** is provided such that it is symmetrical, centering on the axial line of the rotation member **63**. Thus, when the cutting needle **8** and the rotation member **63** are inserted into the first insertion hole of one of the guide portions **711** to **714**, the first protruding portion **631** and the second protruding portion **632** are guided by one of the first guide surfaces **851** to **854** and one of the second guide surfaces **861** to **864** of the guide portions **711** to **714**. As a result, the sewing machine **2** can rotate the cutting needle **8** in an even more stable manner, compared to a case in which only one end of the protruding portion **621** is guided.

Further, by the engagement portion **442** of the plate spring **44** being engaged with one of the plurality of engagement receiving portion **414**, the plate spring **44** urges the support portion **41** in the direction in which the engagement portion **442** engages with the engagement receiving portion **414**. By this urging, the rotation of the rotation member **63** is locked and the rotation of the cutting needle **8** is also locked. The sewing machine **2** can inhibit the cutting needle **8** from rotating unnecessarily when performing the cutwork on the work cloth. As a result, the sewing machine **2** can perform the cutwork on the work cloth in a stable manner.

It should be noted that the present disclosure is not limited to the above-described embodiment and various modifications are possible. For example, in the above-described embodiment, the support portion **700** is formed integrally with the right side portion of the outer frame **11**. In place of the above-described structure, the support portion **700** may be a separate member from the outer frame **11** and may be fixed to the right side portion of the outer frame **11** by a screw or by adhesive.

In the above-described embodiment, the support portion **700** is provided with the four guide portions **711** to **714** whose extending direction angles differ by 45 degrees, respectively. In place of the above-described structure, six guide portions may be provided whose extending direction angles differ by 30 degrees, respectively. In this case, the angle of the cutting blade of the cutting needle **8** can be adjusted at 30 degree intervals. Further, each of the shape, the size, the number and the extending direction angle of the guide portion may be changed as appropriate.

In the above-described embodiment, the protruding portion **621** is a shaft member that penetrates through the rotation member **63**. In place of the above-described structure, the protruding portion may be formed integrally with the rotation member **63**.

What is claimed is:

1. A sewing machine comprising:

a needle bar driving mechanism configured to move a needle bar in a first direction;

an embroidery frame movement mechanism configured to receive an embroidery frame, and configured to move the embroidery frame along a second direction crossing the first direction, wherein the embroidery frame comprises a protruding portion that protrudes outward from the embroidery frame;

a cutting needle rotation mechanism comprising:

a cutting needle;

a cam member to which the cutting needle is fixed, and the cam member being rotatable around an axial line of the needle bar, and comprising a plurality of cams, the plurality of cams being arranged in mutually adjacent positions therebetween in the first direction, each of the plurality of cams comprising a cam surface portion that comprises a width in the first direction and

a support mechanism configured to support the cam member on the needle bar rotatably;

a processor; and

a memory configured to store computer-readable instructions that cause the sewing machine to:

set a height of the needle bar to a specific position from a plurality of positions, each of the plurality of positions representing that each of the plurality of cams is able to contact the protruding portion;

instruct the needle bar driving mechanism to move the needle bar to the specific position; and

instruct the embroidery frame movement mechanism to move the embroidery frame along the second direction to a predetermined position where the protruding portion is able to contact one of the plurality of cams.

2. The sewing machine according to claim **1**, wherein

the cam surface portion of each of the plurality cams is arranged along a rotational direction of the plurality of cams at a specific distance between each of the plurality of cams.

3. The sewing machine according to claim **1**, wherein the support mechanism comprises:

a support member configured to be detachably mounted on the needle bar, the support member comprising a plurality of engagement portions disposed on the support member at a specific distance along a rotational direction of the plurality of cams,

a fixing member to which the cam member is fixed, and

an elastic member having an urging force between the fixing member and the support member, one end side of the elastic member being configured to engage with any one of the plurality of engagement portions, and another end side of the elastic member being fixed on the fixing member.

4. A sewing machine comprising:

a needle bar driving mechanism configured to move a needle bar in a first direction;

an embroidery frame movement mechanism configured to receive an embroidery frame and configured to move the embroidery frame along a second direction and a third direction crossing the first direction, wherein the embroidery frame comprises a plurality of protruding portions, each of the plurality of protruding portions being disposed on the embroidery frame along the third direction, each of the plurality of protruding portions protruding outward from the embroidery frame;

a cutting needle rotation mechanism comprising:

a cutting needle;

a cam member to which the cutting needle is fixed, and the cam member being rotatable around an axial line of the needle bar, and comprising a plurality of cams, the plurality of cams being arranged in mutually adjacent positions therebetween in the first direction, each of the plurality of cams comprising a cam surface portion that comprises a width in the first direction and

a support mechanism configured to support the cam member on the needle bar rotatably;

a processor; and

a memory configured to store computer-readable instructions that cause the sewing machine to: instruct the embroidery frame movement mechanism to move the embroidery frame along the second direction and the third direction to a specific position where one of the plurality of protruding portions is able to contact one of the plurality of cams.

5. A sewing machine comprising:

a needle bar driving mechanism configured to move a needle bar in a first direction;

a cutting needle rotation mechanism comprising:

a cutting needle;

a base member comprising a protruding member protruding along a particular direction to be separated from the needle bar; and

a support member configured to support the base member on the needle bar rotatably;

an embroidery frame movement mechanism configured to receive an embroidery frame and configured to move the embroidery frame along a second direction crossing the first direction, the embroidery frame comprising a plurality of guide portions, each of the plurality of guide portions configured to engage with the protruding member,

a processor; and

a memory configured to store computer-readable instructions that cause the sewing machine to:

set a specific position of the embroidery frame to a predetermined position from a plurality of positions, each of the plurality of positions representing that each of the plurality of guide portions is able to engage with the protruding member;

instruct the embroidery frame movement mechanism to move the embroidery frame to the specific position; and

instruct the needle bar driving mechanism to move the needle bar in the first direction.

6. The sewing machine according to claim **5**, wherein each of the plurality of guide portions comprises:

an insertion hole configured to allow the cutting needle and the base member to be inserted, and

a guide surface inclined downward along a circumferential direction of the insertion hole.

7. The sewing machine according to claim **6**, wherein

the protruding member comprises:

a first protruding portion protruding along a first particular direction to be separated from the needle bar; and

a second protruding portion protruding along a second particular direction to be separated from the needle bar, wherein the first particular direction and the second particular direction are opposite directions, and

the guide surface comprises:

a first guide surface configured to guide the first protruding portion; and

a second guide surface configured to guide the second protruding portion.

8. The sewing machine according to claim **5**, wherein

the support member is configured to be detachably mounted on the needle bar, and

the support member comprises:

a plurality of engagement portions disposed on the support member at a specific distance along a rotational direction of the axial line of the needle bar, and

an elastic member having an urging force between the base member and the support member, one end side of the elastic member is configured to engage with any one of the plurality of engagement, and another end side of the elastic member is fixed on the base member.

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